

# High Performance Liquid Chromatography in Phytochemical Analysis

Edited by

**Monika Waksmundzka-Hajnos**

*Medical University of Lublin*

*Lublin, Poland*

**Joseph Sherma**

*Lafayette College  
Easton, Pennsylvania, U.S.A.*



**CRC Press**

Taylor & Francis Group

Boca Raton London New York

---

CRC Press is an imprint of the  
Taylor & Francis Group, an Informa business

# Contents

Preface.....	xiii
Editors .....	xv
Contributors .....	xvii

## PART I

<b>Chapter 1</b> Overview of the Field of High Performance Liquid Chromatography in Phytochemical Analysis and the Structure of the Book .....	3
<i>Monika Waksmundzka-Hajnos and Joseph Sherma</i>	
<b>Chapter 2</b> Herbal Drugs and the Role of Chromatographic Methods in Their Analysis .....	13
<i>Ioanna Chinou</i>	
<b>Chapter 3</b> Plant Products in Nutrition and Dietary Supplements: Quality Control.....	23
<i>Grażyna Zgórka</i>	
<b>Chapter 4</b> HPLC in Chemosystematics.....	63
<i>Renate Spitaler and Christian Zidorn</i>	
<b>Chapter 5</b> Phytochemistry, Phytopharmacology, and the Biological Role of Plant Metabolites .....	89
<i>Krystyna Skalicka-Woźniak, Michał Ł. Hanos, and Kazimierz Głowniak</i>	
<b>Chapter 6</b> Sample Preparation of Plant Material .....	107
<i>Anna Oniszczuk and Anna Hawrył</i>	
<b>Chapter 7</b> Stationary Phases and Columns in Analysis of Primary and Secondary Metabolites.....	151
<i>Fred Rabel</i>	
<b>Chapter 8</b> Separation of Nonionic Analytes: Reversed- and Normal-Phase HPLC.....	185
<i>Miroslaw Hawrył and Wojciech Markowski</i>	
<b>Chapter 9</b> Separation of Ionic Analytes: Reversed-Phase, Ion-Pair, Ion-Exchange, and Ion-Exclusion HPLC.....	195
<i>Monika Waksmundzka-Hajnos and Łukasz Cieśla</i>	

<b>Chapter 10</b>	Gradient Elution and Computer-Assisted Method Development .....	211
	<i>Miroslaw Hawryl</i>	
<b>Chapter 11</b>	LC-MS as a Method of Identification and Quantification of Plant Metabolites .....	257
	<i>Günther Stecher, Robert Mayer, Thomas Ringer, Muhammad A. Hashir, Saowapak Kasemsook, Muhammad N. Qureshi, and Günther K. Bonn</i>	
<b>Chapter 12</b>	LC-NMR and Related Techniques for the Rapid Identification of Plant Metabolites.....	287
	<i>Jean-Luc Wolfender</i>	
<b>Chapter 13</b>	Photodiode Array (PDA) and Other Detection Methods in HPLC of Plant Metabolites.....	331
	<i>Wojciech Markowski and Monika Waksmundzka-Hajnos</i>	
<b>Chapter 14</b>	Quantitative Analysis—Method Validation—Quality Control .....	351
	<i>Pierre Masson</i>	
<b>Chapter 15</b>	Confirmation of Chirality of Some Natural Products by the HPLC Method .....	373
	<i>Beata Polak</i>	

## **PART II**

### **Primary Metabolites**

<b>Chapter 16</b>	HPLC of Carbohydrates .....	399
	<i>Angelika Koch, Simla Basar, and Rita Richter</i>	
<b>Chapter 17</b>	HPLC of Plant Lipids .....	425
	<i>Marek Gołębiowski, Monika Paszkiewicz, Łukasz Haliński, and Piotr Stepnowski</i>	
<b>Chapter 18</b>	HPLC Analysis of Amino Acids, Peptides, and Proteins .....	453
	<i>Giuseppe Mennella, Antonietta D'Alessandro, and Gianluca Francesc</i>	

### **Secondary Metabolites — *Shikimic Acid Derivatives***

<b>Chapter 19</b>	Application of HPLC in the Analysis of Phenols, Phenolic Acids, and Tannins.....	477
	<i>Tuulia Hyötyläinen and Maarit Kivilompolo</i>	

<b>Chapter 20</b> Application of HPLC in Coumarin Analyses .....	513
<i>Alev Tosun and Petr Tomek</i>	

<b>Chapter 21</b> HPLC of Flavonoids.....	535
<i>Monika Waksmundzka-Hajnos, Anna Oniszczuk, Mieczysław Hajnos, and Tomasz Oniszczuk</i>	

<b>Chapter 22</b> HPLC of Lignans .....	563
<i>Annika I. Smeds</i>	

## **Secondary Metabolites — Isoprenoids**

<b>Chapter 23</b> HPLC of Mono- and Sesquiterpenes .....	579
<i>Angelika Koch, Simla Basar, and Rita Richter</i>	

<b>Chapter 24</b> HPLC Analysis of Diterpenes.....	605
<i>Michał Ł. Hajnos</i>	

<b>Chapter 25</b> High Performance Liquid Chromatography of Triterpenes (Including Saponins) .....	639
<i>Wiesław Oleszek and Anna Stochmal</i>	

<b>Chapter 26</b> HPLC of Carotenoids .....	659
<i>Lukasz Cieśla</i>	

<b>Chapter 27</b> HPLC of Steroids .....	679
<i>Laurence Dinan, Juraj Harmatha, and René Lafont</i>	

<b>Chapter 28</b> HPLC of Iridoids.....	709
<i>Rilka Taskova, Tetsuo Kokubun, and Kalina Alipieva</i>	

## **Secondary Metabolites — Amino Acid Derivatives**

<b>Chapter 29</b> HPLC of Indole Alkaloids .....	731
<i>Anna Petrucczynik</i>	

<b>Chapter 30</b> HPLC of Isoquinoline Alkaloids .....	769
<i>László Kursinszki, Hajnalka Hank, Ágnes Kéry, and Éva Szőke</i>	

<b>Chapter 31</b>	HPLC of Tropane Alkaloids .....	803
	<i>Tomasz Mroczek</i>	
<b>Chapter 32</b>	HPLC of Alkaloids from the Other Biosynthetic Groups.....	823
	<i>Jolanta Flieger</i>	
 <b><i>Secondary Metabolites — Compounds Derived from Acetogenine (Acetylcoenzyme A)</i></b>		
<b>Chapter 33</b>	HPLC Analysis of Polyacetylenes.....	887
	<i>Lars P. Christensen and Kathrine B. Christensen</i>	
<b>Chapter 34</b>	HPLC of Quinonoid Phytochemicals.....	917
	<i>Subhalakshmi Ghosh, Madhushree Das Sarma, and Banasri Hazra</i>	
<b>Index.....</b>		947