

Methods in Enzymology

Volume 213

Carotenoids

Part A

*Chemistry, Separation, Quantitation, and
Antioxidation*

EDITED BY

Lester Packer

DEPARTMENT OF MOLECULAR AND CELL BIOLOGY
UNIVERSITY OF CALIFORNIA, BERKELEY
BERKELEY, CALIFORNIA



ACADEMIC PRESS, INC.
Harcourt Brace Jovanovich Publishers
San Diego New York Boston
London Sydney Tokyo Toronto

Table of Contents

CONTRIBUTORS TO VOLUME 213	ix
PREFACE	xiii
VOLUMES IN SERIES	xv

Section I. Chemistry: Synthesis, Properties, and Characterization

1. Carotenoids: An Overview	HANSPETER PFANDER	3
2. Synthesis and Characterization of Carotenoids by Different Methods	MASAYOSHI ITO, YUMIKO YAMANO, AND YUKO SHIBATA	13
3. Structure and Characterization of Carotenoids from Various Habitats and Natural Sources	TAKAO MATSUNO	22
4. Surface-Enhanced Raman Scattering Spectroscopy of Photosynthetic Membranes and Complexes	MICHAEL SEIBERT, RAFAEL PICOREL, JAE-HO KIM, AND THERESE M. COTTON	31
5. Synthesis of Carotenoids Specifically Labeled with Isotopic Carbon and Tritium	ARNOLD A. LIEBMAN, WALTER BURGER, SATISH C. CHOUDHRY, AND JOSEPH CUPANO	42
6. Synthesis of Deuterated β -Carotene	H. ROBERT BERGEN, III	49
7. Formation of Volatile Compounds by Thermal Degradation of Carotenoids	J. CROUZET AND P. KANASAWUD	54
8. Analysis of the Formation of Carotene Chromophore and Ionone Rings in <i>Narcissus pseudonarcissus</i> L. Chromoplast Membranes	PETER BEYER AND HANS KLEINIG	62
9. C_{50} Bicyclic Carotenoids: Sarcinaxanthin Synthesis	J. P. FÉRÉZOU	75
10. Synthesis of Carotenoporphyrin Models for Photosynthetic Energy and Electron Transfer	DEVENS GUST, THOMAS A. MOORE, ANA L. MOORE, AND PAUL A. LIDDELL	87
11. Use of Borohydride Reduction Methods to Probe Carotenoid-Protein Binding	R. GÓMEZ AND J. C. G. MILICUA	100
12. Gas-Phase Reaction Mass Spectrometric Analysis of Carotenoids	WILLIAM R. LUSBY, FREDERICK KHACHIK, GARY R. BEECHER, AND JAMES LAU	111

13. Formation of Nonvolatile Compounds by Thermal Degradation of β -Carotene: Protection by Antioxidants	CLAUDETTE BERSET AND CLAIRE MARTY	129
14. Natural Sources of Carotenoids from Plants and Oils	AUGUSTINE S. H. ONG AND E. S. TEE	142
15. Distribution of Carotenoids	T. W. GOODWIN	167

Section II. Separation and Quantitation

16. Stability of β -Carotene under Different Laboratory Conditions	GIORGIO SCITA	175
17. Carotenoid Reversed-Phase High-Performance Liquid Chromatography Methods: Reference Compendium	NEAL E. CRAFT	185
18. Separation and Quantification of Carotenoids in Human Plasma	FREDERICK KHACHIK, GARY R. BEECHER, MUDLAGIRI B. GOLI, WILLIAM R. LUSBY, AND CHARLES E. DAITCH	205
19. Measurement of Carotenoids in Human and Monkey Retinas	GARRY J. HANDELMAN, D. MAX SNODDERLY, ALICE J. ADLER, MARK D. RUSSETT, AND EDWARD A. DRATZ	220
20. Isolation of Fucoxanthin and Peridinin	JARLE ANDRÉ HAUGAN, TORUNN AAKERMAN, AND SYNNØVE LIAAEN-JENSEN	231
21. Preparative High-Performance Liquid Chromatography of Carotenoids	GEORGE W. FRANCIS	246
22. Profiling and Quantitation of Carotenoids by High-Performance Liquid Chromatography and Photodiode Array Detection	A. P. DE LEENHEER AND H. J. NELIS	251
23. Mammalian Metabolism of Carotenoids Other Than β -Carotene	MICHELLE M. MATHEWS-ROTH AND NORMAN I. KRINSKY	265
24. Extraction and Analysis by High-Performance Liquid Chromatography of Carotenoids in Human Serum	ARUN B. BARUA AND HAROLD C. FURR	273
25. Analysis of Apocarotenoids and Retinoids by Capillary Gas Chromatography-Mass Spectrometry	HAROLD C. FURR, ANDREW J. CLIFFORD, AND A. DANIEL JONES	281
26. Separation of Isomers of <i>cis</i> - β -Carotenes	KIYOSHI TSUKIDA	291

27. Proton Nuclear Magnetic Resonance and Raman Spectroscopies of <i>cis-trans</i> -Carotenoids from Pigment-Protein Complexes	YASUSHI KOYAMA	298
28. Electron Paramagnetic Resonance Studies of Carotenoids	HARRY A. FRANK	305
29. Identification of Carotenoid Pigments in Birds	JOCELYN HUDON AND ALAN H. BRUSH	312
30. Fast-Atom Bombardment and Continuous-Flow Fast-Atom Bombardment Mass Spectrometry in Carotenoid Analysis	HAROLD H. SCHMITZ, RICHARD B. VAN BREEMEN, AND STEVEN J. SCHWARTZ	322
31. High-Resolution Analysis of Carotenoids in Human Plasma by High-Performance Liquid Chromatography	GARRY J. HANDELMAN, BINGHUA SHEN, AND NORMAN I. KRINSKY	336
32. Separation and Quantitation of Carotenoids in Foods	FREDERICK KHACHIK, GARY R. BEECHER, MUDLAGIRI B. GOLI, AND WILLIAM R. LUSBY	347
33. Distribution of Macular Pigment Components, Zeaxanthin and Lutein, in Human Retina	RICHARD A. BONE AND JOHN T. LANDRUM	360
34. Carotenoid Glycoside Ester from <i>Rhodococcus rhodochrous</i>	SHINICHI TAKAICHI AND JUN-ICHI ISHIDSU	366
35. Characterization of Carotenoids in Photosynthetic Bacteria	SHINICHI TAKAICHI AND KEIZO SHIMADA	374
36. Enhancement and Determination of Astaxanthin Accumulation in Green Alga <i>Haematococcus pluvialis</i>	SAMMY BOUSSIBA, LU FAN, AND AVIGAD VONSHAK	386
37. Simultaneous Quantitation and Separation of Carotenoids and Retinol in Human Milk by High-Performance Liquid Chromatography	A. R. GIULIANO, E. M. NEILSON, B. E. KELLEY, AND L. M. CANFIELD	391

Section III. Antioxidation and Singlet Oxygen Quenching

38. Antioxidant Effects of Carotenoids <i>in Vivo</i> and <i>in Vitro</i> : An Overview	PAOLA PALOZZA AND NORMAN I. KRINSKY	403
39. Efficiency of Singlet Oxygen Quenching by Carotenoids Measured by Near-Infrared Steady-State Luminescence	ESTHER OLIVEROS, PATRICIA MURASECCO-SUARDI, ANDRÉ M. BRAUN, AND HANS-JÜRGEN HANSEN	420
40. Assay of Lycopene and Other Carotenoids as Singlet Oxygen Quenchers	PAOLO DI MASCIO, ALFRED R. SANDQUIST, THOMAS P. A. DEVASAGAYAM, AND HELMUT SIES	429

41. Biosynthesis of β -Carotene in <i>Dunaliella</i>	AVIV SHAISH, AMI BEN-AMOTZ, AND MORDHAY AVRON	439
42. Carotenoid Free Radicals	MICHAEL G. SIMIC	444
43. Lipid Hydroperoxide Assay for Antioxidant Activity of Carotenoids	JUNJI TERAO, AKIHIKO NAGAO, DONG-KI PARK, AND BOEY PENG LIM	454
44. Antioxidant Radical-Scavenging Activity of Carotenoids and Retinoids Compared to α -Tocopherol	MASAHIKO TSUCHIYA, GIORGIO SCITA, HANS-JOACHIM FREISLEBEN, VALERIAN E. KAGAN, AND LESTER PACKER	460
45. Epoxide Products of β -Carotene Antioxidant Reactions	DANIEL C. LIEBLER AND TODD A. KENNEDY	472
46. Techniques for Studying Photoprotective Function of Carotenoid Pigments	MICHELINE M. MATHEWS-ROTH	479
AUTHOR INDEX		485
SUBJECT INDEX		503