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Chromatography for Foods and Beverages

Vitamin and Antioxidant Applications Notebook

Proven Analytical Methods for the Highest Safety and Quality

Thermo SCIENTIFIC

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Chapter 10: Vitamins and Antioxidants

Introduction

Vitamins are essential organic compounds that an organism needs in limited amounts for normal growth and health. As the organism is unable to synthesize these compounds, they must be obtained through the diet. Vitamin deficiency can lead to disease. Although supplementation is important for the treatment of certain health problems, whether it is of nutritional benefit when used by otherwise healthy people remains unresolved. Low molecular weight antioxidants are organic compounds that prevent key biomolecules from undergoing oxidative damage. They include vitamins as well as non-essential molecules obtained from the diet or synthesized by the organism.

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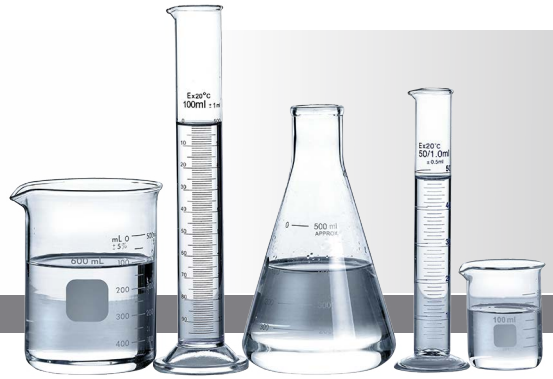

Analytical Technologies

High-Performance Liquid Chromatography

Thermo Scientific™ Dionex™ UltiMate™ 3000 UHPLC+ systems offer excellent chromatographic performance, operational simplicity and unrivaled flexibility. Choose from a wide range of standard and unique specialty detectors to extend your laboratory's analytical capabilities.

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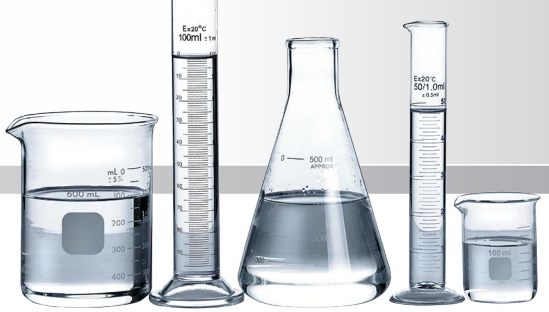

UltiMate 3000 UHPLC+ Systems

Best-in-class HPLC systems for all your chromatography needs

UltiMate 3000 UHPLC+ Systems provide excellent chromatographic performance while maintaining easy, reliable operation. The basic and standard analytical systems offer ultra HPLC (UHPLC) compatibility across all modules, ensuring maximum performance for all users and all laboratories.

Covering flow rates from 20 nL/min to 10 mL/min with an industry-leading range of pumping, sampling, and detection modules, UltiMate 3000 UHPLC+ Systems provide solutions from nano to semipreparative, from conventional LC to UHPLC.

Superior chromatographic performance

- UHPLC design philosophy throughout nano, standard analytical, and rapid separation liquid chromotography (RSLC)
- 620 bar (9,000 psi) and 100 Hz data rate set a new benchmark for basic and standard analytical systems
- RSLC systems go up to 1000 bar and data rates up to 200 Hz
- ×2 Dual System for increased productivity solutions in routine analysis
- Fully UHPLC compatible advanced chromatographic techniques
- Thermo Scientific™ Dionex™ Viper™ and nanoViper™ fingertight fittings—the first truly universal, fingertight fitting system even at UHPLC pressures

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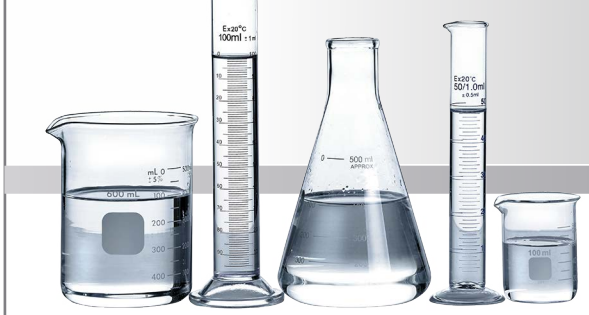

UltiMate 3000 UHPLC+ Systems

We are uniquely focused on making UHPLC technology available to all users, all laboratories, and for all analytes.

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Rapid Separation LC Systems
The extended flowpressure footprint of the RSLC system provides the performance for ultrafast high-resolution and conventional LC applications.

Standard LC Systems
Choose from a wide variety of standard LC systems for demanding LC applications at nano, capillary, micro, analytical, and semipreparative flow rates.

RSLCnano Systems
The Rapid Separation nano LC System (RSLCnano) provides the power for high resolution and fast chromatography in nano, capillary, and micro LC.

Basic LC Systems
UltiMate 3000 Basic LC Systems are UHPLC compatible and provide reliable, high performance solutions to fit your bench space and your budget.

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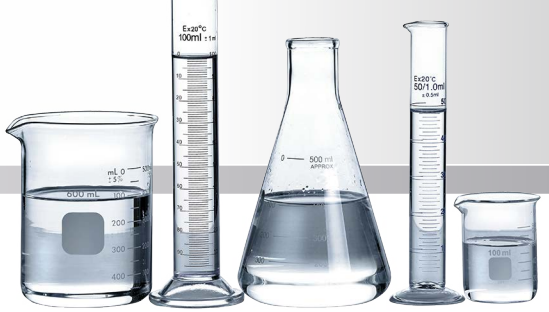

Standard HPLC Detectors

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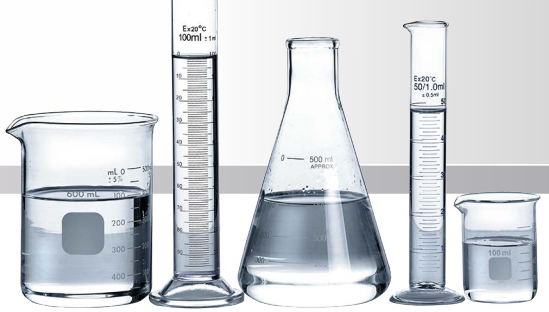
UltiMate 3000 Variable Wavelength Detectors

The Thermo Scientific Dionex UltiMate 3000 VWD-3000 is a variable wavelength detector (VWD) series for industry leading UV-Vis detection. The forward optics design and wide range of available flow cells ensure optimal performance over a flow rate range of five orders of magnitude. Automated qualification, performance optimization, and instrument wellness monitoring deliver maximum uptime, simplify work-flow, and give you full confidence in your analytical results. The detector is available in a standard 100 Hz (VWD-3100) and a 200 Hz Rapid Separation version (VWD-3400RS) for the most challenging UHPLC applications.

High-Performance UV-Vis Detection

- The VWD-3400RS variant provides data collection rates of up to 200 Hz for optimal support of today's and tomorrow's UHPLC separations
- The VWD-3100 standard detector operates at up to 100 Hz data rate for optimum support of 62 MPa (9000 psi) UltiMate 3000 Standard systems
- Superior detection of trace analytes with low noise (< –2.0 µAU) and drift (< 100 µAU/h)
- The detector's large linearity range of up to 2.5 AU is ideal for applications with widely varying analyte concentrations
- Up to four absorption channels (VWD-3400RS) and spectral scans support effective method development
- Active temperature control of optics and electronics for data acquisition independent of ambient conditions
- Front panel access for quick and easy lamps and flow cells changes
- Automated qualification monitoring for full regulatory compliance
- Large front panel display for monitoring the detector status even from a distance
- Maximize uptime using predictive performance–based on monitoring the life cycle of detector lamps
- The detector can be upgraded with the Thermo Scientific Dionex pH/Conductivity Monitor (PCM-3000) for accurate and precise pH- and conductivity monitoring
- Unique 45 nL ultra-low dispersion UV monitor for dispersion-free UV detection in LC/MS

UltiMate 3000 VWD-3400 Variable Wavelength Detector.



Standard HPLC Detectors

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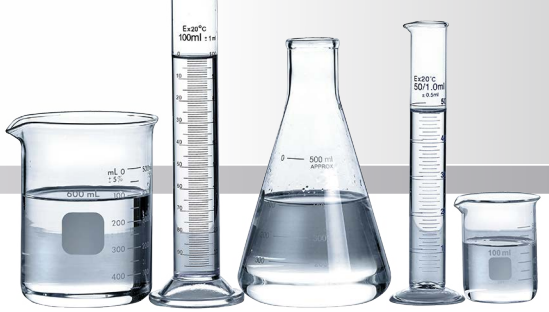
UltiMate 3000 Diode Array and Multiple-Wavelength Detectors

The Thermo Scientific Dionex UltiMate DAD 3000 detector is a high-resolution, 1024-element diode array detector (DAD) available in Rapid Separation (200 Hz) and Standard (100 Hz) versions. It operates with the Thermo Scientific™ Dionex™ Chromeleon™ Chromatography Data System (CDS) software to provide a variety of spectra views, including 3-D plotting and automated chromatogram handling. The high resolution and low-noise performance of the DAD-3000 family makes it ideal for the most sensitive and accurate library searches and peak purity analyses.

The detector is also available as a multiple wavelength detector (MWD) in Standard (100 Hz) and Rapid Separation (200 Hz) versions.

- Data collection at up to 200 Hz using a maximum of eight single-wavelength data channels and one 3-D field (3-D only with DAD-3000 (RS)) for best support of ultrafast separations
- Standard versions operate at up to 100 Hz data collection rate for optimum support of 62 MPa (9000 psi) UltiMate 3000 Standard systems
- Accurate compound confirmation with a 1024-element, high resolution photodiode array
- Flexibility in both UV and Vis applications with 190–800 nm wavelength range
- Low-noise over the full spectral range using deuterium and tungsten lamps
- Fast and accurate wavelength verification using a built-in holmium oxide filter
- The detector can be upgraded with the UltiMate PCM 3000 for accurate monitoring pH gradients
- Excellent reliability and reproducibility with low baseline drift (typically < 500 µAU/h)
- Simplified routine maintenance with front access to pre-aligned cells and lamps
- ID chips on flow cells and lamps for identification and life-span monitoring
- Chromeleon CDS software for full control and flexible data handling
- Front-panel display for easy monitoring of detector status to maximize uptime
- Flow cells for semi-micro, semi-analytical, analytical, and semi-preparative applications
- Flow cells available in stainless steel and biocompatible versions

UltiMate 3000 DAD-3000 Diode Array Detector



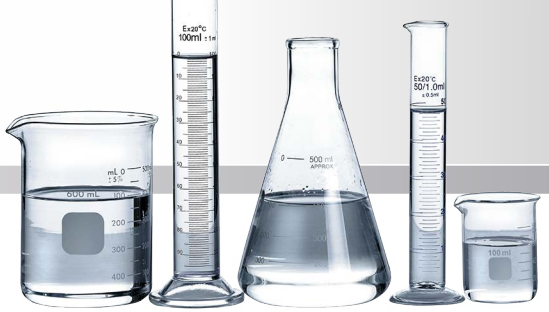
Standard HPLC Detectors

RefractoMax 521 Refractive Index Detector

The Thermo Scientific RefractoMax 521 Refractive Index Detector from ERC Inc. This detector, in combination with the UltiMate 3000 system, is the right choice for the isocratic analysis of sugars, polymers, and fatty acids. It features fast baseline stabilization and excellent reproducibility, combined with high sensitivity. The RefractoMax 521 is fully controlled by the Chromeleon CDS, and can also operate in stand-alone mode.

- The detector is highly sensitive and applicable universally. It provides very stable baselines with a drift of 0.2 µRIU/h and a noise specification of 2.5 nRIU or less
- The optical bench, thermostatically regulated from 30 °C to 55 °C, and the superior signal-to-noise ratio ensure highly precise measurement results
- The extended flow rate range from 1 mL/min up to 10 mL/min and the operating range of 1.00 to 1.75 RIU enable the use of this detector for a wide range of applications
- Applications include the analysis of all compounds with low UV-Vis activity, such as alcohols, mono- and polysaccharides, esters, fatty acids, or polymers
- An Auto Set-up function automates purging, equilibration, autozero, and the control baseline stability and noise
- Operation with Chromeleon CDS makes the detector easy to use and ensures maximum productivity in instrument control, data processing, and reporting of results

RefractoMax 521 Refractive Index Detector



Specialty HPLC Detectors

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Corona Veo Charged Aerosol Detector

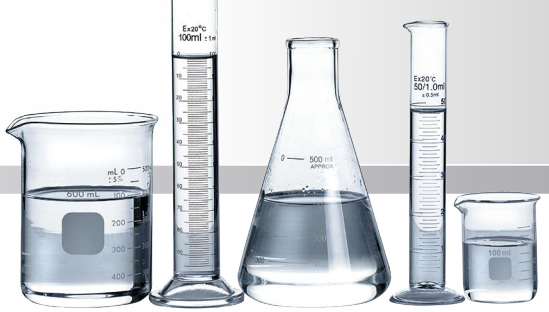
Charged Aerosol Detection provides near universal detection independent of chemical structure for non- or semi-volatile analytes with HPLC and UHPLC. A Thermo Scientific™ Dionex™ Corona™ Veo™ Charged Aerosol detector is ideally suited as a primary detector for any laboratory, while providing complementary data to UV or MS methods. No other LC detector available today can match the performance of a Corona Veo detector.

- High sensitivity – single-digit nanogram on column
- Consistent response – independent of chemical structure
- Wide dynamic range – to four orders of magnitude or greater
- Simple to use – easy to integrate with any HPLC/UHPLC system

The Corona Veo detector gives the simplicity, reproducibility and performance required for a full range of applications from basic research to manufacturing QC/QA. With charged aerosol detection you get predictable responses to measure analytes in direct proportion to their relative amounts for quantitation without actual standards.

This detector offers the flexibility to use reversed-phase gradients, as well as normal phase and HILIC modes of separation on any LC system. And, in many cases eliminates the need for derivatization or sample pre-treatment to provide real dilute-and-shoot simplicity.

Corona Veo Charged Aerosol Detector



Specialty HPLC Detectors

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Ultimate 3000 Electrochemical Detector

Electrochemical detection delivers high sensitivity for neurotransmitter analysis, simplicity and robustness for pharmaceutical or clinical diagnostics, and the selectivity for the characterization of complex samples such as natural products, biological tissues and fluids. For today's researcher, there is a continuing need for detecting vanishingly small quantities of analyte and often in complex samples. Because electrochemical detection measures only compounds that can undergo oxidation or reduction it is both highly sensitive and very selective.

The Thermo Scientific Dionex UltiMate 3000 Electrochemical Detector, designed by the pioneers of coulometric electrochemical detection, delivers state-of-the-art sensor technologies complete with an entire range of high performance and ultra-high performance LC systems optimized for electrochemical detection. The UltiMate 3000 ECD-3000RS takes electrochemical detection to the next level with UHPLC compatibility, total system integration, and selection of detection mode, all with unprecedented operational simplicity.

Features include:

- Detection Modes – choose from DC and PAD for optimum analyte response
- Choice of sensors – both coulometric and amperometric sensors to meet the demands of any application
- UHPLC compatibility – ultralow peak dispersion and high data acquisition rates for conventional or fast, high resolution chromatography
- Modularity – easily expandable to multiple independent sensors for unrivaled flexibility
- Autoranging – simultaneously measure both low and high levels of analytes without losing data
- SmartChip™ technology – easy operation with automatic sensor recognition, event logging and electrode protection

UltiMate 3000 Electrochemical Detector

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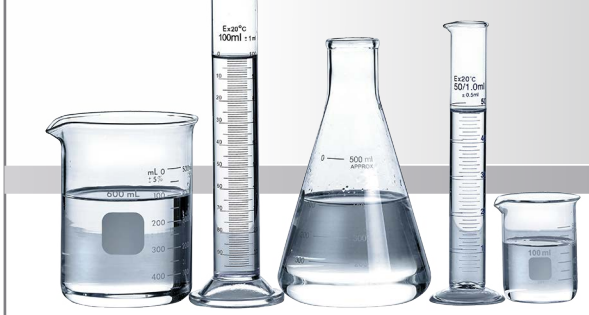
Learn more at www.thermoscientific.com/ECDetection



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Specialty HPLC Detectors

CoulArray Multi-electrode Array Detector

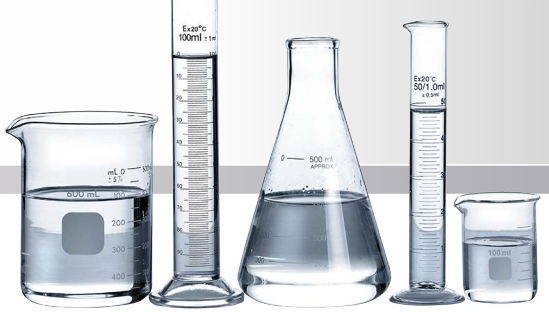
The Thermo Scientific™ Dionex™ CoulArray™ Multi-electrode Array detector is the only practical multi-channel electrochemical detection system that allows you to measure multiple analytes simultaneously, including those that are chromatographically unresolved. The CoulArray detector delivers the widest dynamic range of any available electrochemical detector with unmatched selectivity for detection of trace components in complex matrixes, even when used with aggressive gradients.

- Measures analytes from femtomole to micromole levels
- Greatly simplify sample preparation and eliminate interferences
- Simultaneously analyze multiple analytes in very complex samples
- Easily produce qualitative information for compound identification

Multiple system configurations offer 4, 8, 12, or 16 channels that can be upgraded anytime. The unique data acquisition and processing software uses automatic signal ranging and a unique patented baseline correction algorithms to provide identification and quantitation of single or multiple analytes and powerful 3D data for quick sample fingerprint confirmation with integration to pattern recognition platforms.

With the power of coulometric array technology, the CoulArray detector can give you the qualitative data of a optical PDA with 1,000 fold greater sensitivity to profile the characteristic qualities of products, determine integrity, identify adulteration and even evaluate competitors' products.

CoulArray Multi-electrode Array Detector



Specialty HPLC Detectors

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Ultimate 3000 Fluorescence Detector

The Thermo Scientific Dionex UltiMate 3000 FLD-3000 is a high-sensitivity fluorescence detector series for UltiMate 3000 HPLC systems. It is available in Rapid Separation (RS) and Standard (SD) versions. The optics of the FLD-3000 series provide maximum stray-light suppression for best detection sensitivity. Operated with the Chromeleon CDS software, the detector provides automated qualification, various tools for method development, and instrument wellness monitoring for ease of use, maximum uptime, and the highest degree of regulatory compliance.

- Data collection at up to 200 Hz for optimal support of even the fastest UHPLC separations (FLD-3400RS)
- Standard detectors operate at up to 100 Hz data rate for optimum support of 62 MPa (9,000 psi) UltiMate 3000 standard systems
- Lowest limits of detection with a Raman signal-to-noise ratio (S/N): > 550 ASTM (> 2100 using dark signal as noise reference)
- Unsurpassed reproducibility with active flow cell temperature control for stable fluorophore activity independent of changes in ambient temperature
- Long-life xenon flash lamp for highest sensitivity and long-term operation without the need for frequent lamp changing
- Optional second photomultiplier (PMT) for unique Dual-PMT operation, offering an extended wavelength range up to 900 nm without sacrificing sensitivity in the standard wavelength range
- Two-dimensional (2D) or three dimensional (3D) excitation, emission, or synchro scans to provide the highest degree of flexibility for method development or routine sample characterization
- Innovative Variable Emission Filter for real-time compound-related sensitivity optimization (FLD-3400RS only)
- Large front-panel display for easy monitoring of the detector status
- Two flow-cell sizes for easy optimization to application requirements: the 8 µL flow cell is ideal for trace analysis, and the 2 µL flow cell offers best peak resolution with narrow-bore HPLC and UHPLC columns

Ultimate 3000 Fluorescence Detector

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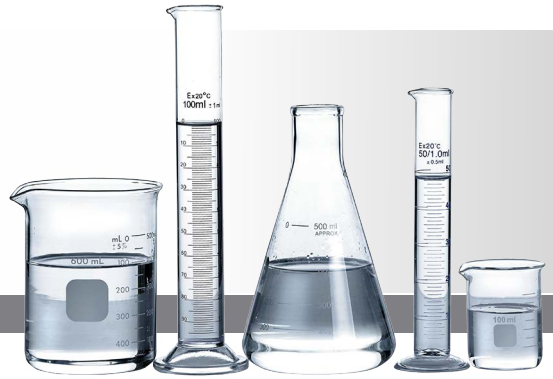

Analytical Technologies

Ion Chromatography

Thermo Scientific Dionex IC systems have led the analytical instrument industry for over 30 years with solutions that represent state-of-the art technological advancements and patented technologies.

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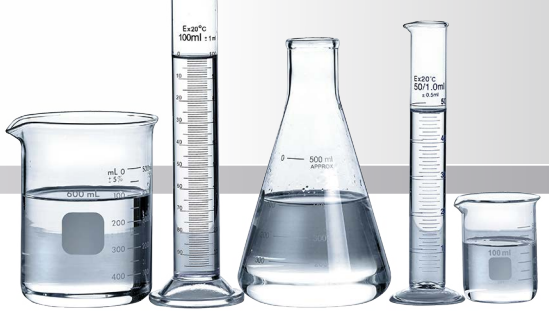

IC and RFIC Systems

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Innovative Ion Chromatography Solutions

Our High-Pressure™ Ion Chromatography (HPIC™) systems include the Thermo Scientific Dionex ICS-5000+ HPIC system, which is optimized for flexibility, modularity, and ease-of-use, combining the highest chromatographic resolution with convenience. In addition, the Thermo Scientific Dionex ICS-4000 Capillary HPIC system is the world's first commercially available dedicated capillary high-pressure Reagent-Free™ (RFIC™) IC system. The Dionex ICS-4000 system is always ready for the next analysis, delivering high-pressure IC on demand.

Reagent-Free IC systems eliminate daily tasks of eluent and regenerant preparation in turn saving time, preventing errors, and increasing convenience. RFIC-EG systems use electrolytic technologies to generate eluent on demand from deionized water, and to suppress the eluent back to pure water to deliver unmatched sensitivity. RFIC-ER systems are designed to use carbonate, carbonate/ bicarbonate, or MSA eluents for isocratic separations.

At the heart of our ion chromatography portfolio is a unique set of column chemistries that provide high selectivities and efficiencies with excellent peak shape and resolution. Thermo Scientific™ Dionex™ IonPac™ chromatography columns address a variety of chromatographic separation modes including ion exchange, ion exclusion, reversed-phase ion pairing, and ion suppression. Our column chemistries are designed to solve specific applications, and we offer a variety of selectivities and capacities for simple and complex samples. Additionally, our Dionex IonPac column line is available in standard bore, microbore and capillary formats for the ultimate application flexibility.

Thermo Scientific Dionex IC instrument family

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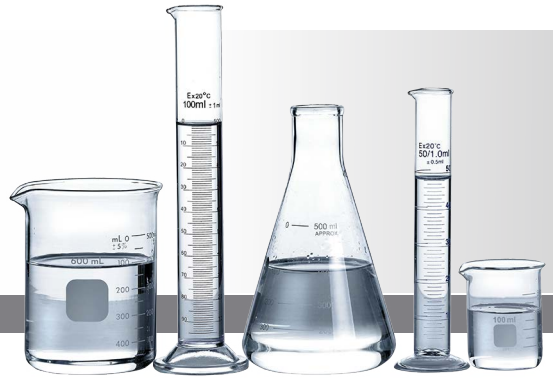

Analytical Technologies

Mass Spectrometry

Thermo Fisher Scientific provides advanced integrated IC/MS and LC/MS solutions with superior ease-of-use and modest price and space requirements. UltiMate 3000 System Wellness technology and automatic MS calibration allow continuous operation with minimal maintenance. The Dionex ion chromatography family automatically removes mobile phase ions for effort-free transition to MS detection.

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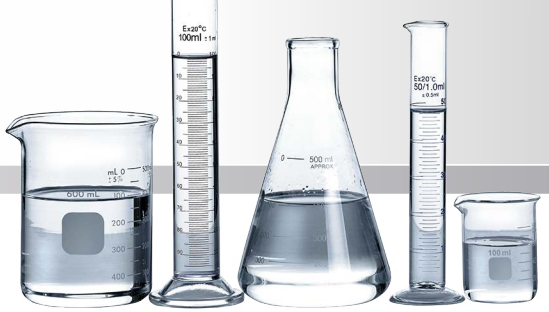

Mass Spectrometry Instruments

Single-Point Control and Automation

Thermo Fisher Scientific provides advanced integrated IC/MS and LC/MS solutions with superior ease-of-use and modest price and space requirements. UltiMate 3000 System Wellness technology and automatic MS calibration allow continuous operation with minimal maintenance. The Dionex ion chromatography family automatically remove mobile phase ions for effort-free transition to MS detection.

- Thermo Scientific™ MSQ Plus™ mass spectrometer, the smallest and most sensitive single quadrupole on the market for LC and IC
- Self-cleaning ion source for low maintenance operation
- Chromeleon CDS software for single-point method setup, instrument control, and data management compatible with existing IC and LC methods
- The complete system includes the MSQ Plus mass spectrometer, PC data system, electrospray ionization (ESI) and atmospheric pressure chemical ionization (APCI) probe inlets, and vaccum system

Now, you no longer need two software packages to operate your LC/MS system. Chromeleon CDS software provides single-software method setup and instrument control; powerful UV, conductivity, and MS data analysis; and fully integrated reporting.

MSQ Plus Mass Spectrometer

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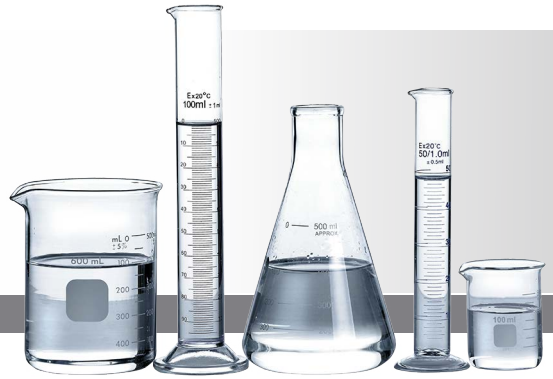

Analytical Technologies

Chromatography Data Systems

Tackle chromatography management challenges with the world's most complete chromatography software. Whether your needs are simple or complex or your scope is a single instrument, a global enterprise, or anything in between – the combination of Chromeleon CDS' scalable architecture and unparalleled ease-of use, makes your job easy and enjoyable with one Chromatography Data System for the entire lab.

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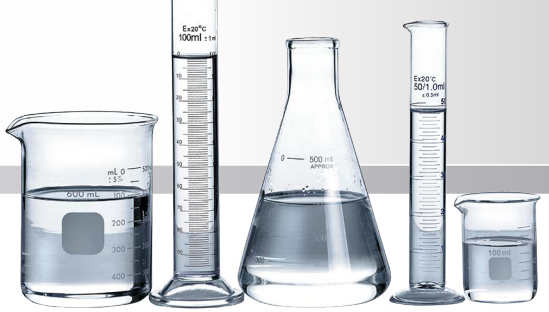

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Chromeleon CDS Software

The Fastest Way from Samples to Results

The 7.2 release of Chromeleon Chromatography Data System software is the first CDS that combines separation (GC/IC/LC) and Mass Spectrometry (MS) in an enterprise (client/server) environment. By extending Chromeleon 7.2 CDS beyond chromatography into MS, lab technicians can now streamline their chromatography and MS quantitation workflows with a single software package. MS support in Chromeleon 7.2 CDS is focused on routine and quantitative workflows, which provides access to rich quantitative data processing and automation capabilities — ultimately boosting your overall lab productivity and increasing the quality of your analytical results.

- Enjoy a modern, intuitive user interface designed around the principle of operational simplicity
- Streamline laboratory processes and eliminate errors with eWorkflows™, which enable anyone to perform a complete analysis perfectly with just a few clicks
- Access your instruments, data, and eWorkflows instantly in the Chromeleon Console
- Locate and collate results quickly and easily using powerful built-in database query features
- Interpret multiple chromatograms at a glance using MiniPlots
- Find everything you need to view, analyze, and report data in the Chromatography Studio
- Accelerate analyses and learn more from your data through dynamic, interactive displays
- Deliver customized reports using the built-in Excel compatible speadsheet

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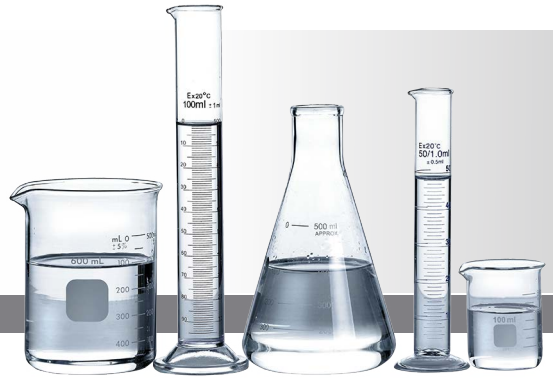

Analytical Technologies

Process Analytical Systems

Thermo Scientific Dionex process analytical systems provide timely results by moving chromatography-based measurements on-line.

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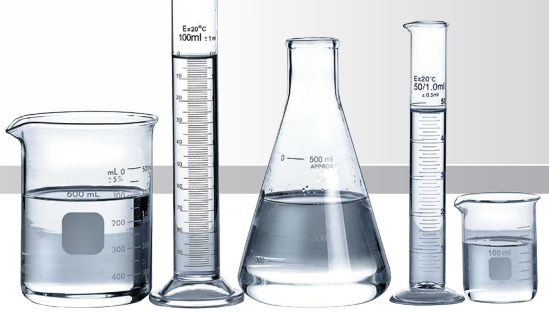

Process Analytical Systems and Software

Improved Process Monitoring with On-line Chromatography IC and LC Systems

Information from the Thermo Scientific Dionex Integral process analyzer can help reduce process variability, improve efficiency, and reduce downtime. These systems provide comprehensive, precise, accurate information faster than is possible with laboratory-based results. From the lab to the factory floor, your plant's performance will benefit from the information provided by on-line LC.

- Characterize your samples completely with multicomponent analysis
- Reduce sample collection time and resources with automated multipoint sampling
- Improve your process control with more timely results
- See more analytes with unique detection capabilities
- The Thermo Scientific Integral Migration Path approach lets you choose the systems that best meets your needs

Integral process analyzer

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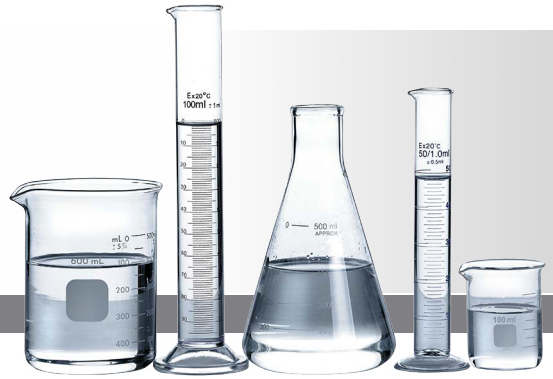

Analytical Technologies

Automated Sample Preparation

Solvent extractions that normally require labor-intensive steps are automated or performed in minutes, with reduced solvent consumption and reduced sample handling using the Thermo Scientific™ Dionex™ ASE™ Accelerated Solvent Extractor system or Thermo Scientific™ Dionex™ AutoTrace™ 280 Solid-Phase Extraction instrument.

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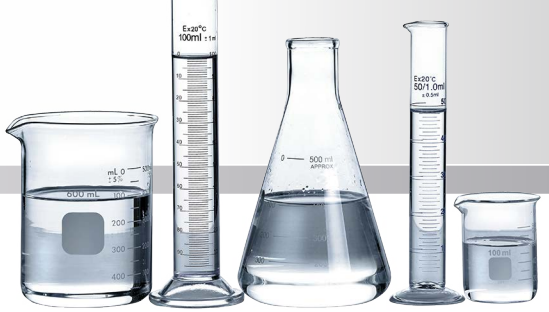

Accelerated Solvent Extractor System

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Complete Extractions in Less Time Using Less Solvent

Thermo Scientific Dionex ASE systems extract of solid and semisolid samples using common solvents at elevated temperature and pressure. The Dionex ASE 150 and 350 systems feature pH-hardened pathways with Dionium™ components to support extraction of acidic or alkaline matrices, and combine pretreatment, solvent extraction, and cleanup into one step. Dionium is zirconium that has undergone a proprietary hardening process that makes it inert to chemical attack by acids and bases at elevated temperatures.

Dionex ASE systems are dramatically faster than Soxhlet, sonication, and other extraction methods, and require significantly less solvent and labor. Accelerated solvent extraction methods are accepted and established in the environmental, pharmaceutical, foods, polymers and consumer product industries. Accelerated solvent extraction methods are accepted and used by government agencies worldwide.

Dionex ASE 150/350 and Dionex AutoTrace 280 SPE instruments

Chapter 10: Vitamins and Antioxidants

Water-Soluble Vitamins

These low molecular weight organic compounds, readily soluble in water, include vitamins B_1 (thiamine), B_2 (riboflavin), B_3 (niacin), B_5 (pantothenic acid), B_6 (pyridoxine), B_7 (biotin), B_9 (folic acid), B_{12} (cobalamin) and C (ascorbic acid). In general, as these vitamins are readily excreted from the body more consistent intake is important. Water-soluble vitamins are a chemically heterogeneous group of compounds and include acids, bases, zwitterions, and neutrals with different chromatographic, spectroscopic, and voltammetric properties. The amounts in samples can vary from a few micrograms to hundreds of milligrams. Each sample presents a unique set of interferences and requires careful selection of preparation procedures.

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Water-Soluble Vitamins

Analysis of a Drink Mix

The Acclaim PolarAdvantage II (PA2) column features an amide embedded functionality in the stationary phase, and provides unique selectivity and aqueous compatibility, making it suitable to separating water-soluble vitamins. The use of the 2.2 µm Acclaim RSLC column in 2.1 mm i.d. format allows fast analysis time with reduced solvent consumption.

The diode array detector confirms the identity and purity of each peak. This example demonstrates that the Acclaim RSLC PA2 column separates eight common water soluble vitamins using a "green" method (isopropanol as the organic modifier) in 5 min. Note that citric acid and other minor components can interfere with ascorbic acid niacin. Carefull adjustment of the mobile phase pH may help to resolve these interferences.

System:	UltiMate 3000 RSLC
Column:	Acclaim RSLC PA2, 2.2 µm
Dimensions:	2.1 × 100 mm
Flow:	0.41 mL/min
Temperature:	25 °C
Injection:	2 µL; bypass mode at 0.15 min
Mobile Phases:	A: 30 mM H_3PO_4 adjusted to pH 3.07 with NH_4OH B: Isopropanol

Gradient:	-4.0	0.0	0.8	3.0	5.0
%A	100	100	100	88	88
%B	0	0	0	12	12

Pressure:	280–430 bar
Detection:	Diode array, UV 210 (shown), 246, 260, 375 nm; spectra 200–450 nm Baseline subtraction with water blank

Peaks:	
1. Thiamine	25 µg/mL
2. Ascorbic acid	25
3. Niacin	25
4. Pyridoxine	25
5. Niacinamide	25
6. Pantothenic acid	25
7. Folic acid	25
8. Riboflavin	10
9. Citrate	–

Traces:	A. Propel® lemon flavor drink mix, 0.40 g in 20 mL water, filtered B. Standards in phosphate buffer

Propel is a registered trademark of PepsiCo

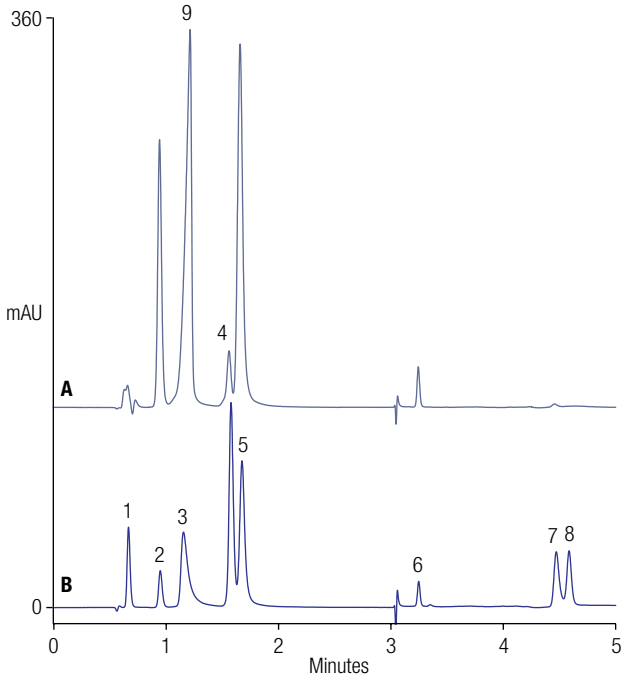

Figure 10-1. Water-soluble vitamins on an Acclaim PolarAdvantage II RSLC column.

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Water-Soluble Vitamins

Analysis of a Supplement

Vitamin supplement tablets are complex formulations with many ingredients. Some vitamins are strongly hydrophilic, so the column needs to operate in 100% aqueous buffer to gain sufficient retention to resolve them from the other sample peaks near the void volume. The Acclaim PA column can do this reliably whereas a hydrophobic C18 column would be likely to suffer dewetting. The multiple wavelength capability of the diode array detector provides primary wavelengths for quantitification and alternate wavelengths for confirmation.

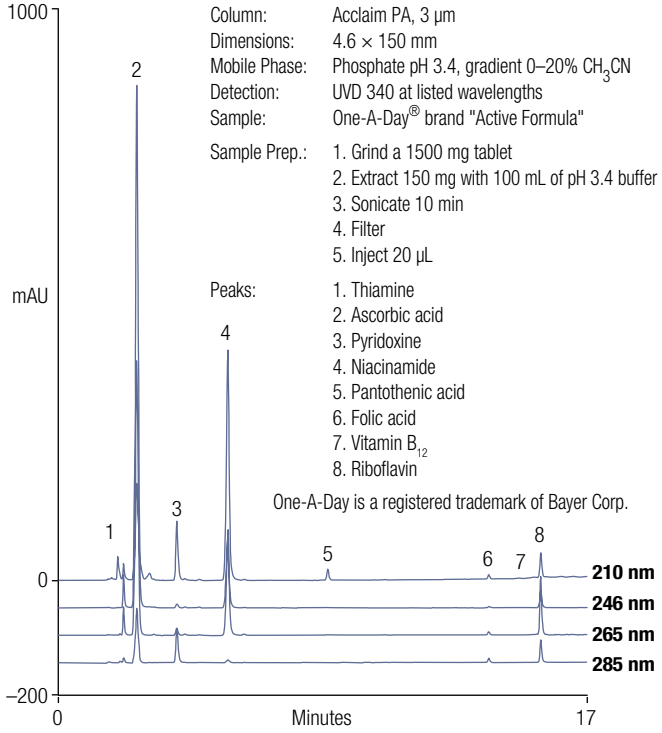

Figure 10-2. Assay for water-soluble vitamins in vitamin tablets using the Acclaim PA column.

Analysis of Amino Acids

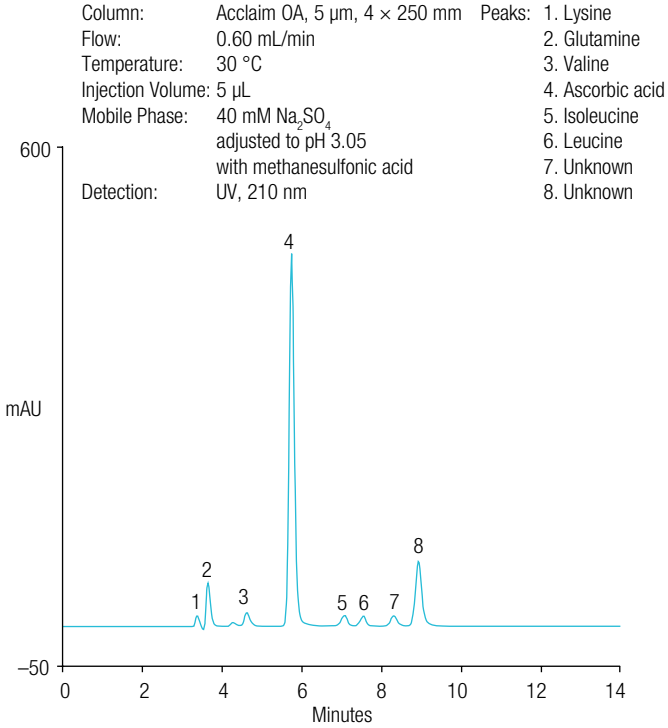

Figure 10-3. Analysis of amino acids in vitamin premix on an Acclaim OA column.

Water-Soluble Vitamins

B Vitamins

Thiamine (B_1), riboflavin (B_2), niacin (B_3), and pyridoxine (B_6) are water soluble vitamins that affect many important biological functions, including metabolism of carbohydrates, fats, and proteins, and maintenance of healthy muscle, skin, eyes, hair, and liver. Because few of us eat completely balanced diets all the time, supplements containing balanced portions of these and many other vitamins may allow us to obtain the recommended amounts of these compounds.

Column:	Acclaim 120 C18, 150 × 4.6 mm
Flow:	1.5 mL/min
ColumnTemp.:	25 °C
Injection Volume:	20 µL
Mobile Phase:	A: (95:5:0.2, v/v/v) Water:methanol: phosphoric acid, 85%+ 10 mM hexanesulfonic acid, pH 4.5 B: (50:50:0.2) Water: methanto: phosphoric acid, 85%+ 10 mM hexanesulfonic acid, pH 4.5
Gradient:	100% A–100% B over 30 min
Detection:	UV, 260 and 290 nm
Sample Preparation:	A suitable amount of finished product is extracted with (95:5:1 v/v/v) Water: acetonitrile, glacial acetic acid
Peaks:	1. Nicianamide (B_3) 2. Pyridoxine (B_6) 3. Thiamine (B_1) 4. Riboflavin (B_2)

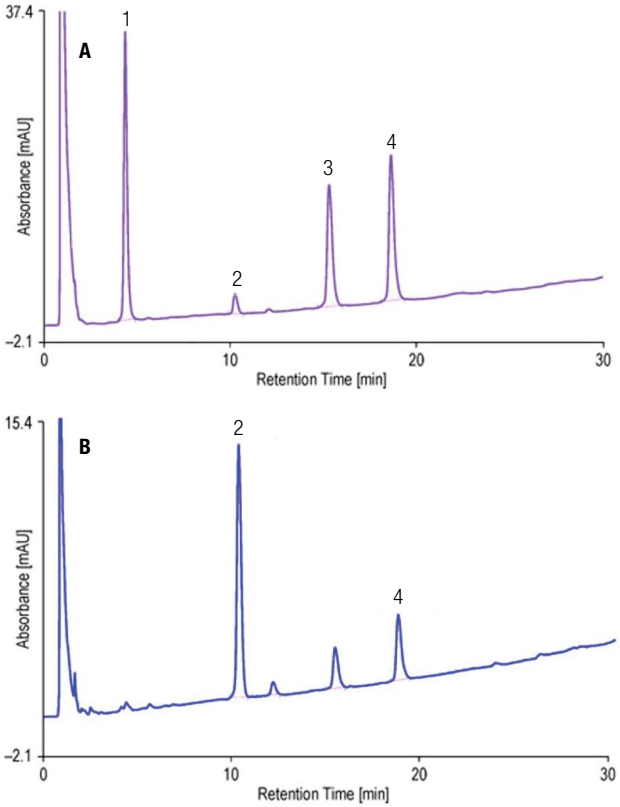

Figure 10-4. Determination of Vitamins B_1, B_2, B_3, and B_6 in dietary supplements. A) UV detection at 260 nm and B) UV detection at 290 nm.

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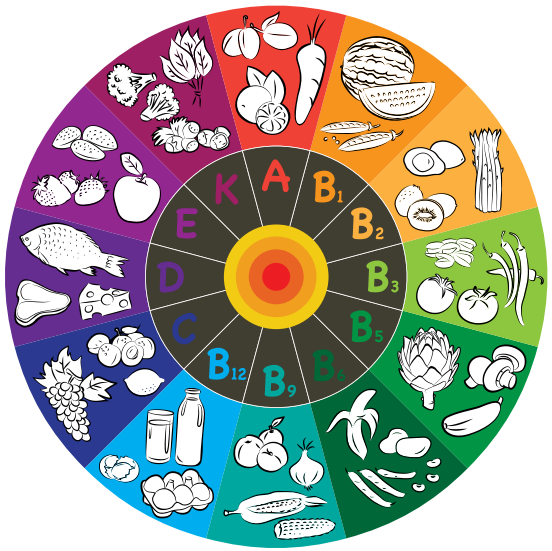
Water-Soluble Vitamins

Vitamin B_{12} – Cobalamin

Cyanocobalamine (Vitamin B_{12}) belongs to the B vitamin group and prevents pernicious anemia, which is caused by Vitamin B_{12} deficiency. Because plant products contain very little Vitamin B_{12}, vegetarians and people who do not eat red meat need to supplement their diet by taking multivitamin tablets and beverages supplemented with Vitamin B_{12}. Excessive consumption of Vitamin B_{12} may cause asthma and folic acid deficiency, therefore, typically only a low level of Vitamin B_{12} (e.g., ng/g) is added to products, thus making direct analysis difficult. As a result, Vitamin B_{12} analysis usually involves complicated sample preparation, which presents challenges for product quality control. This application shows a simple, fast, and effective on-line SPE method, followed by HPLC with UV detection.



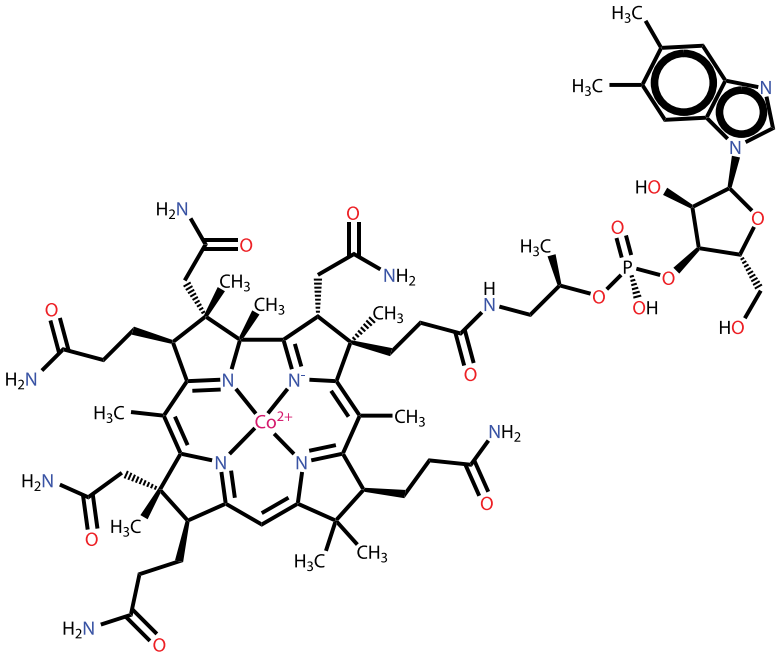


Figure 10-5. Chemical structure of Vitamin B_{12}.

Did You Know?

A few hundred years ago, a sailor on a long voyage would likely not return home alive. This was not because he might die in a storm or be killed by pirates, but because he might develop the disease scurvy. Fortunately, a British doctor found that a daily ration of lime juice would prevent Scurvy along with its softening and bleeding of organs, tendons, skin, and gums that led to death for sailors. Sailors got the nickname "limey" from this practice. Today, it is known that scurvy was caused by vitamin C deficiency. To overcome the inability to store fresh fruits and vegetables on ship, lime juice provided the vitamin C the sailors needed.

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Water-Soluble Vitamins

Vitamin B_{12} – Cobalamin

SPE Column:	Acclaim PA2, 3 µm, 3.0 × 33 mm
Anal. column:	Acclaim PA2, 3 µm, 3.0 × 150 mm
Flow:	0.6 mL/min for SPE and separation
ColumnTemp.:	30 °C
Injection Volume:	2500 µL on SPE column
Eluent for SPE:	CH_3CN – 25 mM phosphate buffer (pH 3.2) in gradient
Eluent for Separation:	CH_3CN – 25 mM phosphate buffer (pH 3.2) in gradient
Detection:	UV at 361 nm
Chromatograms:	1. Water blank 2. Beverage sample 3. The same sample spiked with 0.45 ng/mL of Vitamin B_{12} standard

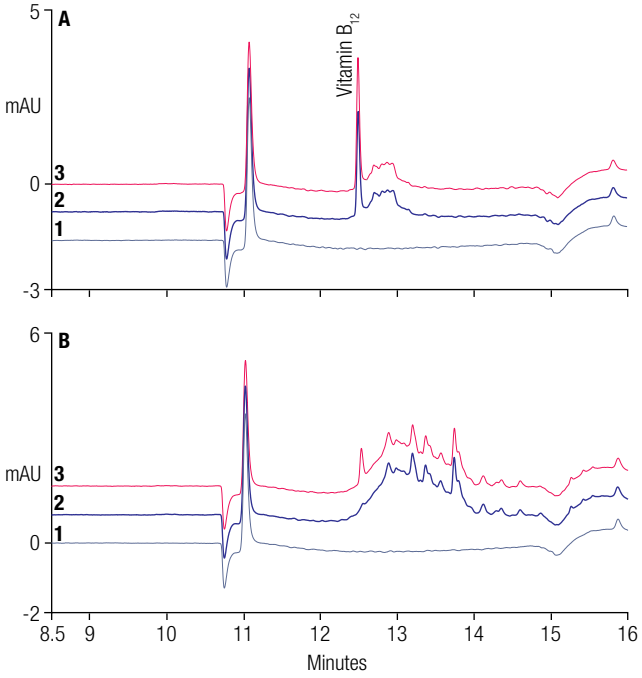


Figure 10-6. Overlay of chromatograms A) Sample #1 (Orange Flavor H22335) and B) Sample #4 (Peach Flavor A31601).

SPE Column:	Acclaim PA2, 3 µm, 3.0 × 33 mm
Anal. Column:	Acclaim PA2, 3 µm, 3.0 × 150 mm
Flow:	0.6 mL/min for SPE and separation
Column Temp.:	30 °C
Injection Volume:	2500 µL on SPE column
Eluent for SPE:	CH_3CN – 25 mM phosphate buffer (pH 3.2) in gradient
Eluent for Separation:	CH_3CN – 25 mM phosphate buffer (pH 3.2) in gradient
Detection:	UV at 361 nm
Chromatograms:	1. Orange flavor H22335 2. Litchi flavor F10632 3. Kaffir lime flavor F10522 4. Peach flavor A31601 5. Orange flavor H22333 6. Litchi flavor F10014 7. Kaffir lime flavor F12203 8. Peach flavor A41020 9. Peach flavor C10553

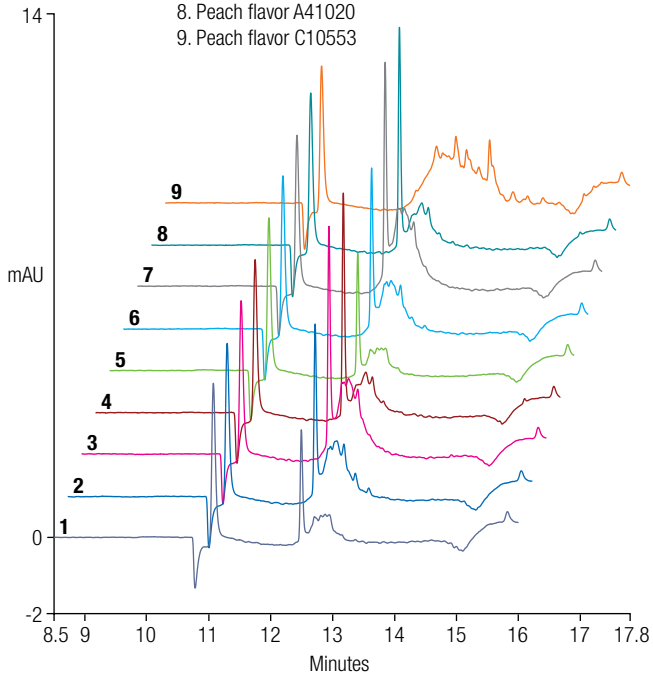
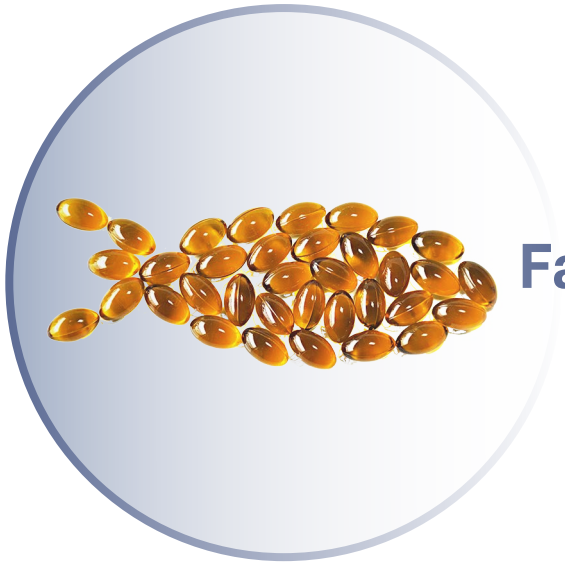


Figure 10-7. Overlay of chromatograms of beverages with different flavors and different batch numbers.

Download Application Note 256: Determination of Vitamin B12 in Beverages Using On-Line SPE Followed by HPLC with UV Detection

Chapter 10: Vitamins and Antioxidants



Fat-Soluble Vitamins

These low molecular weight compounds, readily soluble in lipids, include vitamins A (retinol), D (calciferol), E (tocopherol) and K (phylloquinone). Unlike water-soluble vitamins, they are less efficiently excreted and are more likely to accumulate in the body. Over supplementation can lead to hypervitaminosis. Fat-soluble vitamins play a number of important physiological roles and are involved with bone metabolism, vision, and blood coagulation.

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Fat-Soluble Vitamins

Analysis by Reversed-Phase HPLC-Absorbance Detection

Fat-soluble vitamins and related substances can be efficiently resolved using different Acclaim columns and measured by absorbance detection.

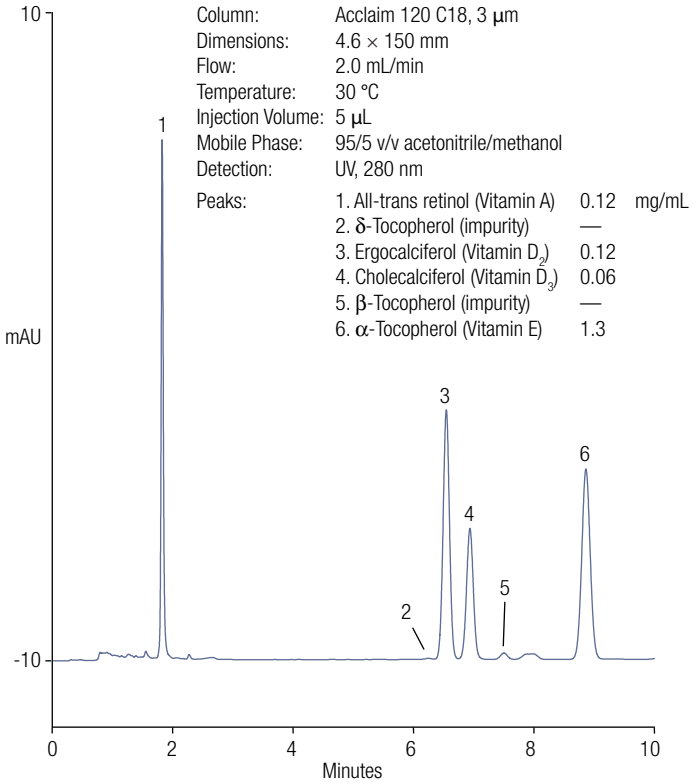
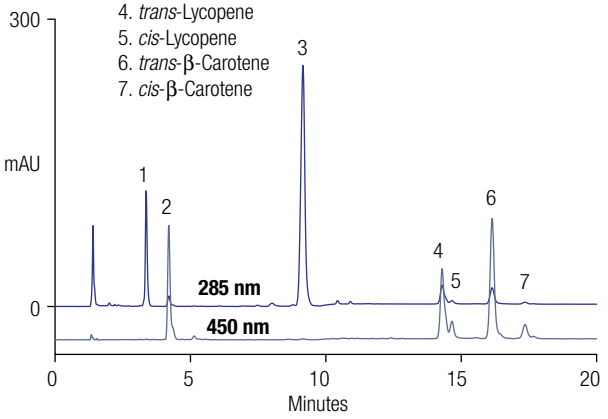


Figure 10-8. Determination of fat-soluble vitamin standards on the Acclaim 120 C18 column.

Column: Acclaim PA C16, 3 µm, 4.6 × 150 mm
Flow: 1.25 mL/min
Temperature: 30 °C
Injection: 10 µL
Mobile Phase: (A) Water
(B) 54:44:2 methanol:acetonitrile:isopropanol
Gradient:

Time	0	8.0	8.1	25
%A	5	5	0	0
%B	95	95	100	100

Detector: Diode array, 450 and 285 nm, and spectra 200–595 nm
Peaks:
1. *trans*-Retinol acetate
2. *trans*-Lutein
3. α-Tocopherol acetate
4. *trans*-Lycopene
5. *cis*-Lycopene
6. *trans*-β-Carotene
7. *cis*-β-Carotene



Sample Prep.:
- Finely grind a weighed tablet
- Take an aliquot of about 1/10 tablet (150 mg)
- Partition between 2.0 mL water and 6.0 mL ethyl acetate with sonication
- Evaporate 2.0 mL of ethyl acetate phase and reconstitute in 1.0 mL mobile phase B

Figure 10-9. Determination of fat-soluble vitamins and carotenoids in a vitamin tablet.

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Fat-Soluble Vitamins

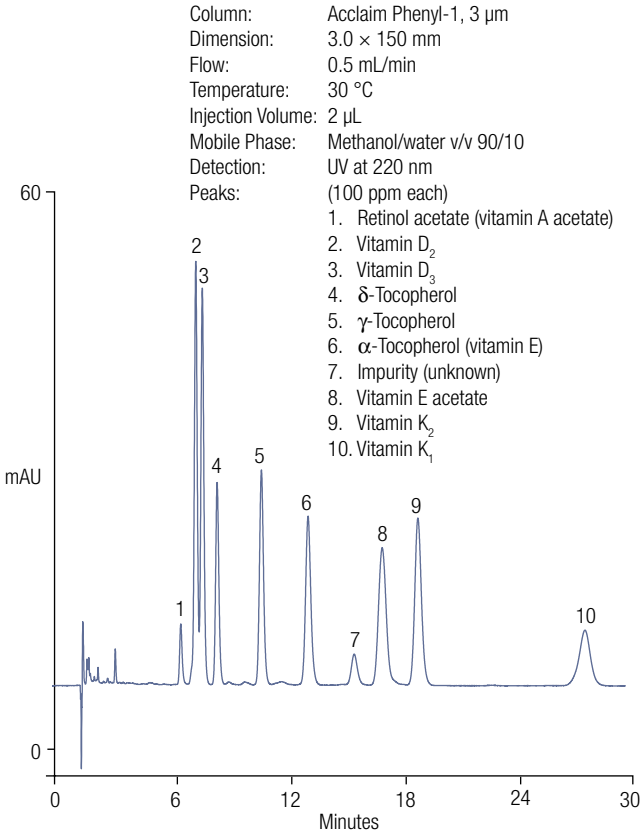

Figure 10-10. Separation of fat-soluble vitamins.

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Fat-Soluble Vitamins

Analysis by Reversed-Phase HPLC-CAD

Shown here is a simple, reversed-phase high-performance liquid chromatography (RP-HPLC)-charged aerosol detection method for the measurement of 11 fat-soluble vitamins (FSV) and fat-soluble antioxidants (FSA) in commercially-available supplements including: vitamins A (trans-retinol, retinyl acetate, and palmitate), E (α-, δ-, γ-tocopherols and succinate), D, and K_1 (phylloquinone); lycopene; lutein; and CoQ10. The analysis was completed in 20 min.

HPLC Column: C8, 150 × 4.6 mm, 2.7 µm
Flow: 1.5 mL/min
Column Temp.: 40 °C
Sample Temp.: 10 °C
Injection Volume: 10 µL
Mobile Phase: A: Methanol/water/acetic acid (750:250:4)
B: Acetonitrile/methanol/tetrahydrofuran/acetic acid (500:375:125:4)

Gradient:

Time	%A	%B
0.0	70	30
1.0	50	50
5.0	40	60
10.0	35	65
12.0	10	90
17.0	0	100
17.1	70	30
20.0	70	30

Detection: Charged aerosol detection
Run Time: 20 min

Peaks:
1. *trans*-Retinol
2. Retinyl acetate
3. Lutein
4. δ-Tocopherol
5. γ-Tocopherol
6. Phylloquinone (K_1)
7. α-Tocopherol
8. Lycopene
9. Retinyl palmitate
10. CoQ10

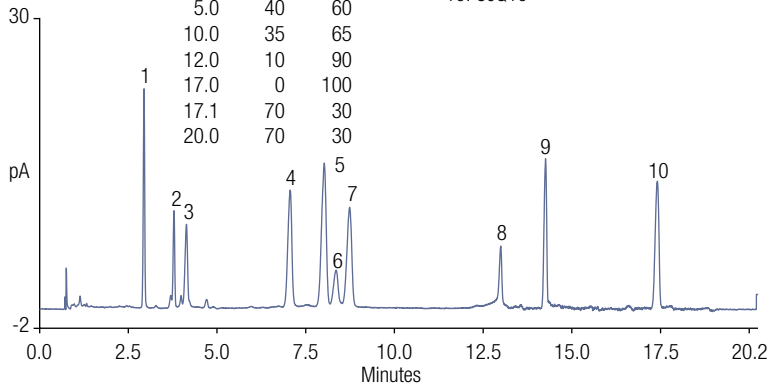

Figure 10-11. RP-HPLC chromatogram of FSV standards (166 ng on column, vitamin K1 at 66 ng).

For Additional Chromatographic Approaches Download:

Application Note 20539: Analysis of Fat Soluble Vitamins Using a Thermo Scientific Accucore XL C18 4 µm HPLC Column

Application Note 20590: Separation of a Mixture of Vitamin K Isomers Using a Solid Core HPLC Column at Sub-ambient Temperature

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Fat-Soluble Vitamins

Vitamin D

Vitamin D is a fat-soluble vitamin. Fat-soluble vitamin supplements are often formulated in an oil-based carrier; e.g. soy oil in a gelatin capsule. This is inconvenient for reversed-phase chromatography because the carrier elutes very late. Normal-phase chromatography elutes the matrix before the vitamins. The Acclaim HILIC-10 column can be operated in its primary HILIC mode, or alternately, in normal-phase mode where it provides good resolution using simple isocratic conditions, and no sample pretreatment.

Vitamins D occurs in two forms – D_2 and D_3 – that are frequently difficult to separate from each other and from Vitamin E. The Acclaim PolarAdvantage II column has an embedded amide group that provides a unique selectivity for some separations. To optimize that selectivity, both the temperature and alcohol content were varied. The RSLC format allows fast separations with good resolution, with only a moderate increase in pressure. The diode-array detector confirms the identity and purity of each peak.

LC System:	UltiMate 3000	Mobile Phase:	Heptane:acetonitrile: isopropanol:acetic acid 98.4:1.0:0.5:0.1(v/v/v)
Column:	Acclaim HILIC-10, 3 µm		
Dimensions:	4.6 × 150 mm	Detection:	PDA (spectra 200–400 nm) Traces at 265 nm shown
Flow:	1.00 mL/min		
Temperature:	30 °C	Samples:	A. 10 µg/mL Vitamin D_3 in heptane B. One capsule (5000 IU) in heptane to make 10 mL
Injection Volume:	20 µL	Peaks:	1. Impurity 2. Vitamin D_3

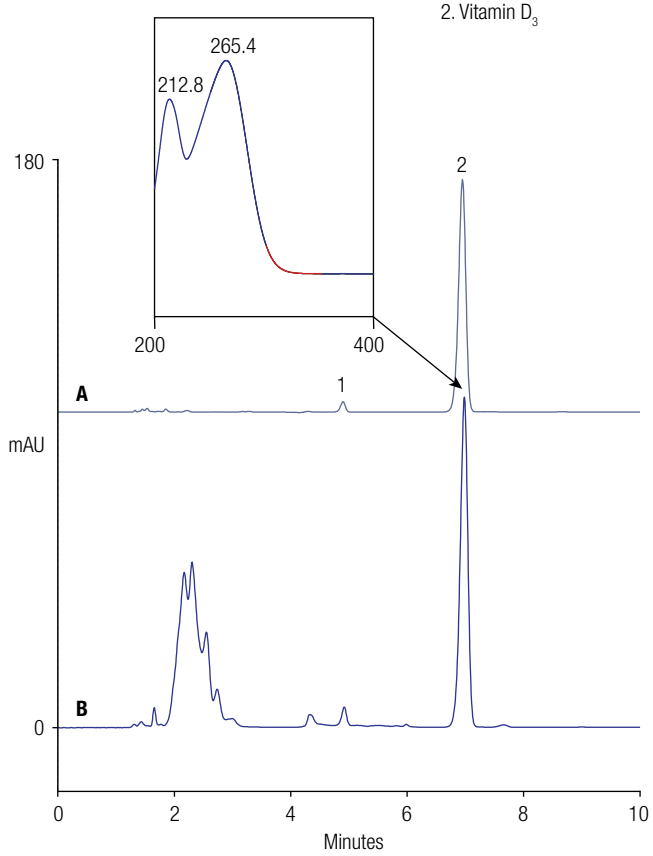

Figure 10-12. Determination of vitamin D_3 in supplements using the Acclaim HILIC-10 column.

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Fat-Soluble Vitamins

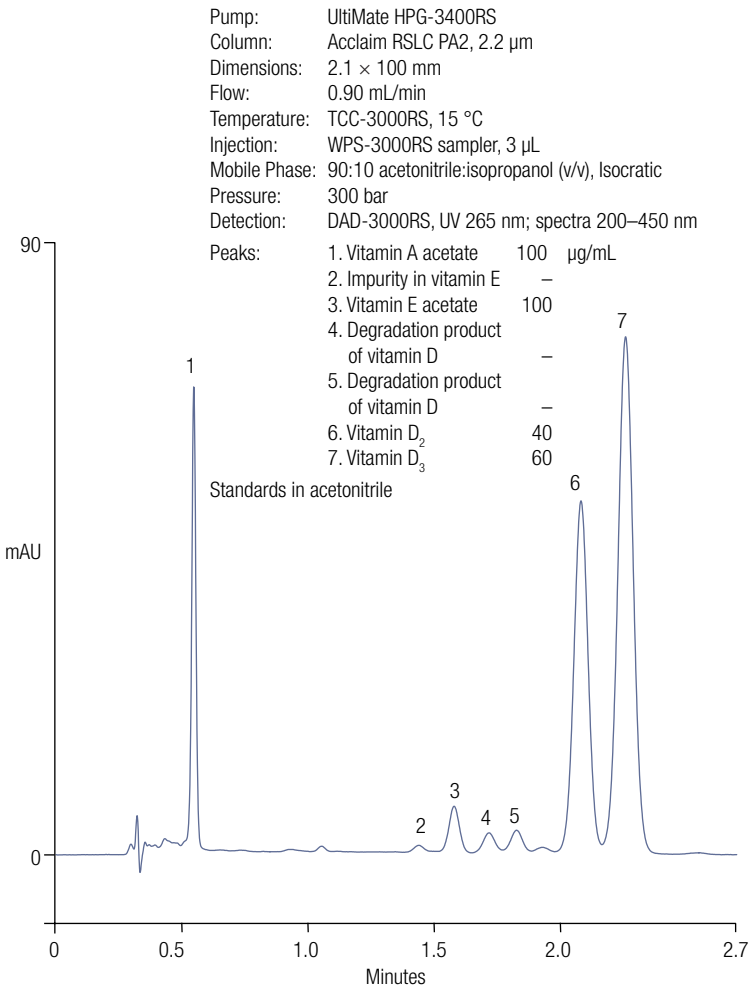

Figure 10-13. Separation of fat-soluble vitamins on Acclaim RSLC PolarAdvantage II column.

Table 1. Diseases associated with vitamin deficiencies.

Disease	Vitamin	Chemical
Beriberi	B_1	Thiamine
Pellagra	B_3	Niacin
Biotin Deficiency	B_7	Biotin
Scurvy	C	Ascorbic acid
Rickets	D	Cholecalciferol
Ariboflavinosis	B_2	Riboflavin
Vitamin K Deficiency	K	Phylloquinone; menaquinone
Hybocobalaminemia	B_{12}	Cobalamin
Paraesthesia	B_5	Pantothenic acid
Night Blindness	A	Retinoic acid

Did You Know?

It has long been known among Eskimos and arctic travelers that the ingestion of polar-bear liver by men and dogs causes severe illness. The reason – Hypervitaminosis A. Bear's liver contains between 24,000 and 35,000 IU vitamin A per gram. For humans the tolerable upper limit for healthy adults is set at 10,000 IU. Signs of toxicity generally occur when approximately 25,000 to 33,000 IU are consumed.

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Fat-Soluble Vitamins

Vitamin E

Vitamin E (α-tocopherol) is an antioxidant compound found in nuts, grains, and leafy green vegetables, and it protects cell membranes and other parts of the cell from damage. Tocopheryl acetate is used to formulate products, and in the body it is converted to the biologically active tocopherol. Fat-soluble vitamins are often formulated in an oil-based carrier. This is inconvenient for reversed-phase chromatography because the carrier elutes very late. Normal-phase chromatography elutes the carrier near the void before the vitamins. The Acclaim HILIC-10 column can be operated in its primary HILIC mode, or alternatively in normal-phase mode where it provides good resolution using simple isocratic conditions.

Column:	Acclaim HILIC-10, 3 µm
Dimensions:	4.6 × 150 mm
Flow:	1.0 mL/min
Temperature:	30 °C
Injection Volume:	5 µL
Mobile Phase:	Heptane:tetrahydrofuran:isopropanol 94.75:5.00:0.25 (v/v/v)
Detection:	UV at 280 nm; spectra 200–400 nm
Peaks:	1. α-Tocopheryl acetate 60 µg/mL
	2. α-Tocopherol 40

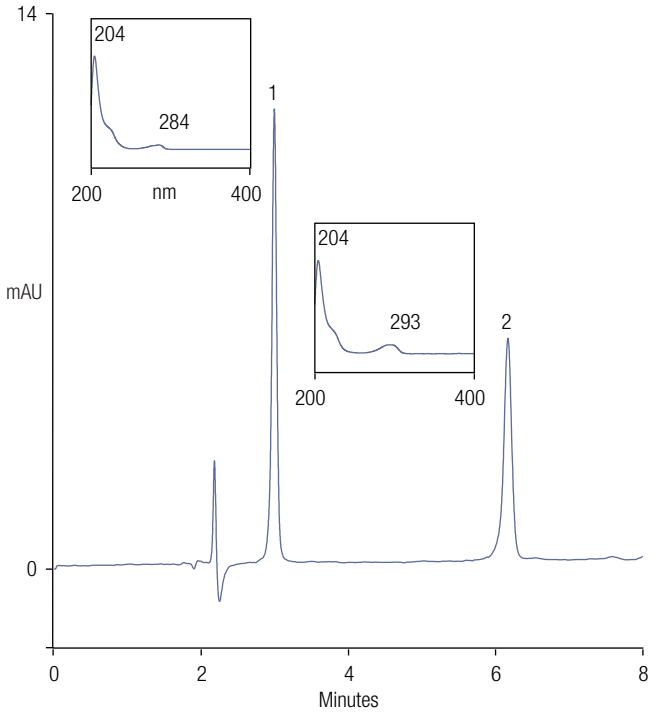

Figure 10-14. α-Tocopherol and α-tocopheryl acetate determination using the Acclaim HILIC-10 column.

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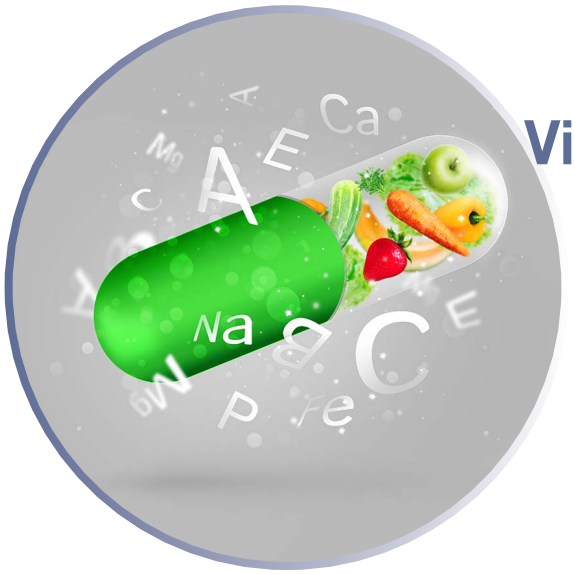
Chapter 10: Vitamins and Antioxidants



Vitamin Mixtures

Traditional analysis of vitamin products requires several different methods to quantify the additives. Water-soluble vitamins are often determined with RP-HPLC using an aqueous mobile phase, while the fat-soluble vitamins use organic solvent mobile phases in both reversed- and normal-phase HPLC methods. Combined methods evaluating both types of vitamins pose a challenge due to the difference in solubility limits of the two classes of vitamins and the many different biologically equivalent compounds that can be added, but are listed as a single vitamin. For example, niacin is available as nicotinic acid and nicotinamide, which are both biologically active and referred to as niacin in product labeling.

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Vitamin Mixtures

Simultaneous Measurement of Water- and Fat-Soluble Vitamins in Functional Waters

The simultaneous determination of a wide range of vitamins increases the complexity of an analytical method. Vitamin structures range from small unconjugated organic acids, such as pantothenic acid (Vitamin B_5) that are minimally UV active, to large complexes that absorb at different wavelengths, such as cyanocobalamine (Vitamin B_{12}). Multiple detection wavelengths are needed to optimize sensitivity due to the chemical diversity of vitamins.

The Acclaim PolarAdvantage II column can be used to determine water- and fat-soluble vitamins in a single method. This column contains a high-efficiency, silica-based, polar-embedded stationary phase manufactured by bonding a proprietary amide-embedded ligand to high-purity spherical silica. It is compatible with 100% aqueous mobile phases over a wide pH range (1.5–10), and provides excellent peak shapes and efficiencies for both basic and acidic compounds.

Functional beverages are vitamin-enhanced waters that have gained consumer popularity for convenience, perceived health benefits, and improved flavor over tap water. These beverages are typically enriched with Vitamin C, B-complex vitamins, and Vitamins A and E, with the advertised benefits of increased energy from the B vitamins and antioxidant benefits from Vitamins A, C, and E. Labeling the nutritional content of these beverages is regulated by the U.S. Food and Drug Administration (US FDA). Therefore, methods are needed to assay the vitamins to support product labeling. Determination of vitamins in foods is inherently difficult and deviation of the determined amounts of a vitamin from labeled amounts has been observed.

Analysis of these beverages presents a challenge due to the presence of both water- and fat- soluble vitamins. Proprietary formulations of vitamins that remain soluble and shelf-stable are used to enrich these beverages. Additionally, gums, preservatives, and other additives are used to emulsify and stabilize the drink.

In this application, a gradient HPLC method using an Acclaim PolarAdvantage II column was used to resolve both water and fat soluble vitamins in functional waters.

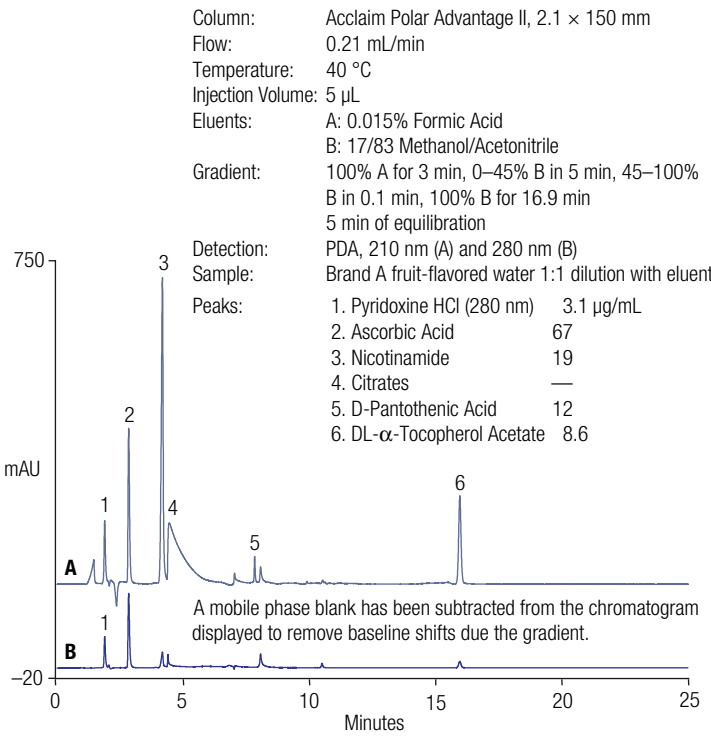

Figure 10-15. Separation of Brand A, a fruit-flavored, artificially-sweetened, vitamin-enhanced water.

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Vitamin Mixtures

Column:	Acclaim Polar Advantage II, 2.1 × 150 mm
Flow:	0.21 mL/min
Temperature:	40 °C
Injection Volume:	5 µL
Eluents:	A: 0.015% Formic Acid B: 17/83 Methanol/Acetonitrile
Gradient:	100% A for 3 min, 0-45% B in 5 min, 45–100% B in 0.1 min, 100% B for 16.9 min 5 min of equilibration
Detection:	PDA, 210 nm (A), 280 nm (B), and 350 nm (inset)
Sample:	Brand C fruit-flavored water 1:1 dilution with eluent A

Peaks:		
	1. Pyridoxine HCl (280 nm)	4.6 µg/mL
	2. Nicotinamide	10
	3. Citrates	—
	4. D-Pantothenic Acid	6.0
	5. DL-α-Tocopherol Acetate	5.3
	6. Retinol Palmitate (inset)	0.44

Baseline corrected, 15% shift in signal intensity between A and B

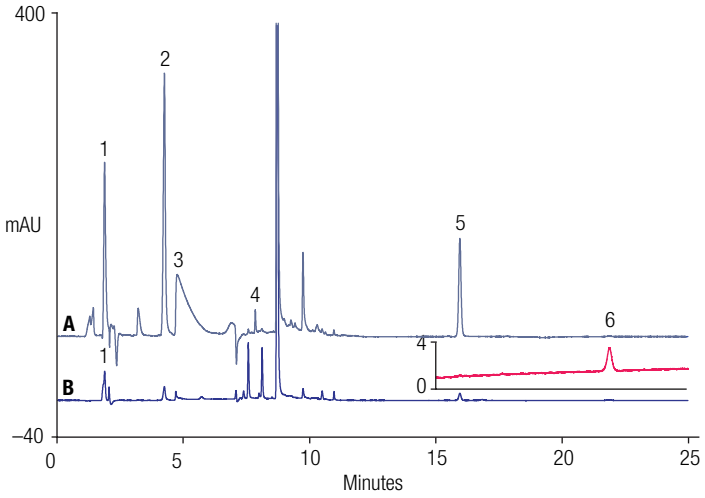

Figure 10-16. Separation of Brand C, a fruit-flavored, sugar- sweetened, vitamin-enhanced water with added natural extracts and caffeine

Did You Know?

Unlike the term organic, 'all natural' is not an official term that is regulated by the federal government and does not offer any guarantee as to the product's safety.

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Vitamin Mixtures

Simultaneous Measurement of Water- and Fat-Soluble Vitamins in Dry Syrup Multivitamin Formulation

Vitamins are vital to human development and long-term health; therefore, infants are usually prescribed a vitamin supplement to ensure they receive the recommended daily allowance of each vitamin. Children under one year of age are usually given this supplement in liquid form. This supplement can be produced as a dry syrup using a powdered preparation to which the pharmacist adds liquid to produce the dosage form for the patient. The work shown here describes an HPLC method to quantify water- and fat-soluble vitamins in a dry syrup.

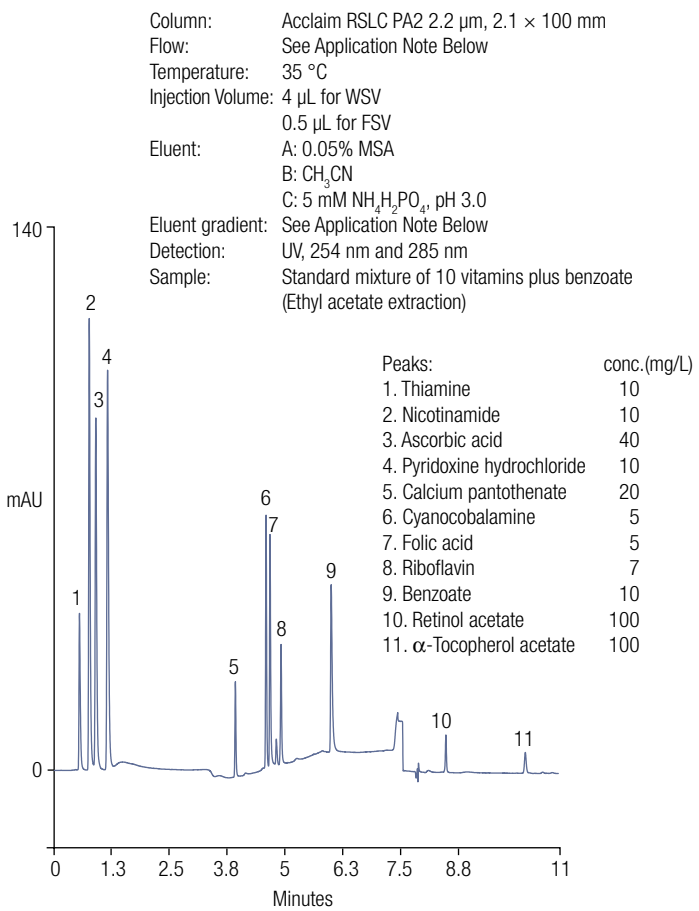
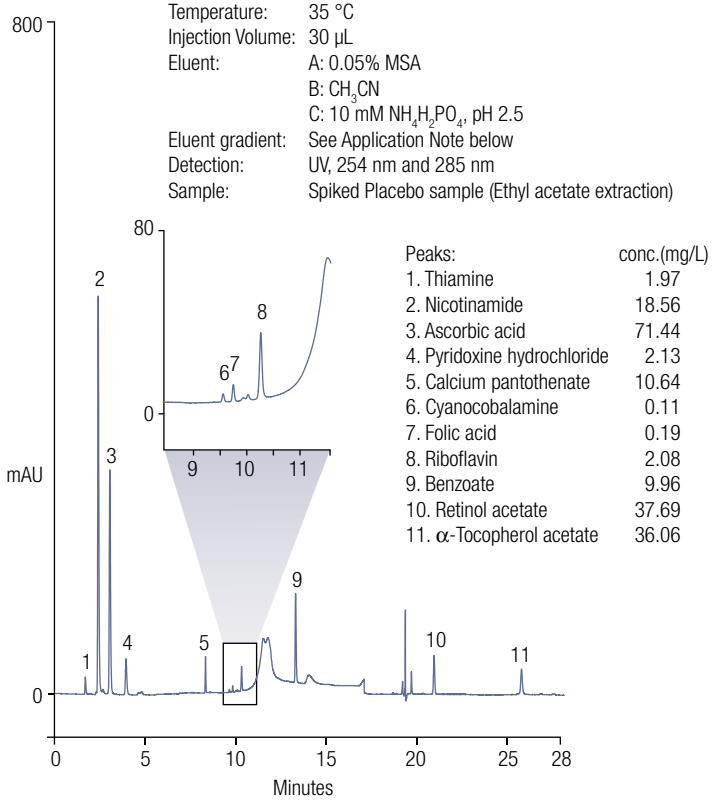


Figure 10-17. Chromatogram of a mixture of 10 vitamins plus benzoate (ethyl acetate extraction).

Download Application Note 252: HPLC Assay of Water-Soluble Vitamins, Fat-Soluble Vitamins, and a Preservative in Dry Syrup Multivitamin Formulation

Vitamin Mixtures

Column:	Acclaim PA2 3 µm, 4.6 × 150 mm
Flow:	See Application Note Below
Temperature:	35 °C
Injection Volume:	30 µL
Eluent:	A: 0.05% MSA B: CH_3CN C: 10 mM $NH_4H_2PO_4$, pH 2.5
Eluent gradient:	See Application Note below
Detection:	UV, 254 nm and 285 nm
Sample:	Spiked Placebo sample (Ethyl acetate extraction)



Peaks:	conc.(mg/L)
1. Thiamine	1.97
2. Nicotinamide	18.56
3. Ascorbic acid	71.44
4. Pyridoxine hydrochloride	2.13
5. Calcium pantothenate	10.64
6. Cyanocobalamine	0.11
7. Folic acid	0.19
8. Riboflavin	2.08
9. Benzoate	9.96
10. Retinol acetate	37.69
11. α-Tocopherol acetate	36.06

Figure 10-18. Chromatogram of the dry syrup sample (ethyl acetate extraction).

Download Application Note 252: HPLC Assay of Water-Soluble Vitamins, Fat-Soluble Vitamins, and a Preservative in Dry Syrup Multivitamin Formulation

Vitamin Mixtures

Simultaneous Measurement of Water- and Fat-Soluble Vitamins in Supplements and Feeds

Columns:	Acclaim PA, 3 µm, 3.0 × 150 mm for water-soluble vitamins Acclaim C18, 3 µm, 3.0 × 150 mm for fat-soluble vitamins
Flow:	0.5 mL/min
Column Temp:	25 °C
Injection Volume:	10 µL
Mobile Phases:	For water-soluble vitamins, A) 25 mM phosphate buffer (pH 3.6), B) CH_3CN-mobile phase A (7:3, v/v) For fat-soluble vitamins, A) CH_3OH-CH_3CN (8 : 2, v/v), B) Methyl tert-butyl ether (MTBE) Both in gradient (Table shown in Technical Note below)
Detection:	UV at different wavelengths for different vitamins (See Table 2 in below Technical Note)

Peaks:

1. Thiamine
2. Vitamin C
3. Nicotinic acid
4. Pyridoxal hydrochloride
5. Pyridoxine hydrochloride
6. Nicotinamide
7. Pantothenic acid
8. Folic acid
9. Cyancobalamin
10. Riboflavin
11. Vitamin A
12. Lutein
13. Vitamin A acetate
14. Vitamin D_2
15. Vitamin D_3
16. Vitamin E
17. Vitamin E acetate
18. Vitamin K_1
19. Lycopene
20. Vitamin A palmitate
21. ß-Carotene

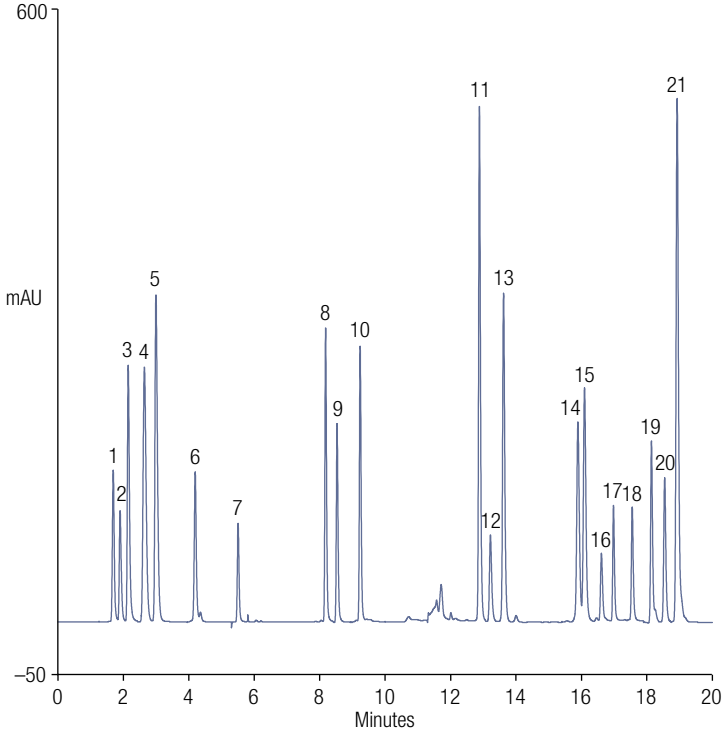


Figure 10-19. Chromatograms of the simultaneous separation of 21 water- and fat-soluble vitamins.

Did You Know?

U.S. consumers spend about 12 billion dollars on vitamins and dietary supplements a year. (1999). Japan with less than half the population of the U.S. spends almost 11 billion dollars a year.

Download Technical Note 89: Determination of Water- and Fat-Soluble Vitamins by HPLC

Vitamin Mixtures

Columns: Acclaim PA, 3 µm, 3.0 × 150 mm for water-soluble vitamins
Acclaim C18, 3 µm, 3.0 × 150 mm for fat-soluble vitamins
Flow Rate: 0.5 mL/min
Column Temp.: 25 °C
Injection Volume: 10 µL
Mobile Phases: For water-soluble vitamins
A) 25 mM phosphate buffer (pH 3.6)
B) CH_3CN-mobile phase A (7:3, v/v)
For fat-soluble vitamins
A) CH_3OH-CH_3CN (8:2, v/v)
B) Methyl *tert*-butyl ether (MTBE)
Both in gradient (Table shown in Technical Note below)
Detection: UV on different wavelengths for different vitamins (See Table 2 in below Technical Note)
Peaks:
1. Thiamine
2. Vitamin C
3. Pyridoxal hydrochloride
4. Pyridoxine hydrochloride
5. Nicotinamide
6. Pantothenic acid
7. Folic acid
8. Cyancobalamine
9. Riboflavin
10. Vitamin A
11. Vitamin A acetate
12. Vitamin D_2
13. Vitamin E
14. Vitamin E acetate
15. Vitamin K_1
16. Vitamin A palmitate
17. ß-Carotene

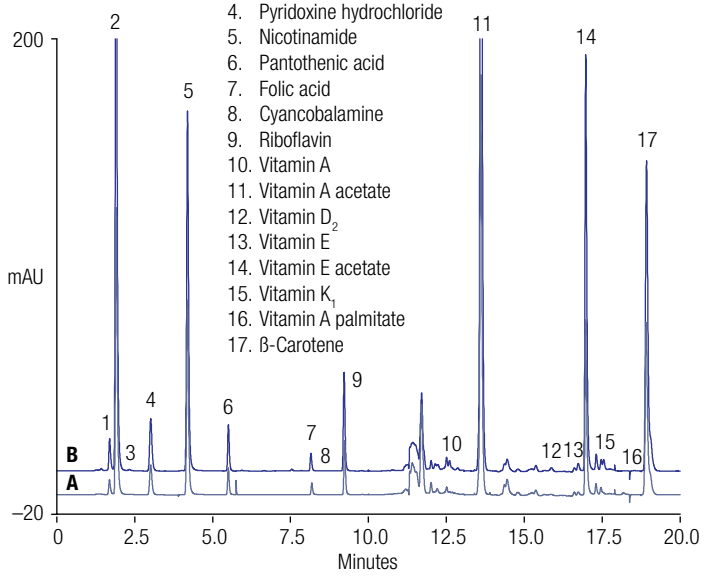


Figure 10-20. Chromatograms of (A) vitamin and mineral supplement tablet (for women) and (B) the same sample spiked with standards. There was a 1000-fold sample dilution for water-soluble vitamins, and a 100-fold dilution for fat-soluble vitamins.

Columns: Acclaim PA, 3 µm, 3.0 × 150 mm for water-soluble vitamins
Acclaim C18, 3 µm, 3.0 × 150 mm for fat-soluble vitamins
Flow Rate: 0.5 mL/min
Column Temp.: 25 °C
Injection Volume: 10 µL
Mobile Phases: For water-soluble vitamins
A) 25 mM phosphate buffer (pH 3.6)
B) CH_3CN-mobile phase A (7:3, v/v)
For fat-soluble vitamins
A) CH_3OH-CH_3CN (8:2, v/v)
B) Methyl *tert*-butyl ether (MTBE)
Both in gradient (Table shown in Technical Note below)
Detection: UV on different wavelengths for different vitamins (See Table 2 in below Technical Note)
Peaks:
1. Thiamine
2. Vitamin C
3. Pyridoxal hydrochloride
4. Pyridoxine hydrochloride
5. Nicotinamide
6. Pantothenic acid
7. Folic acid
8. Riboflavin
9. Vitamin A acetate
10. Vitamin D_2
11. Vitamin E acetate
12. ß-Carotene

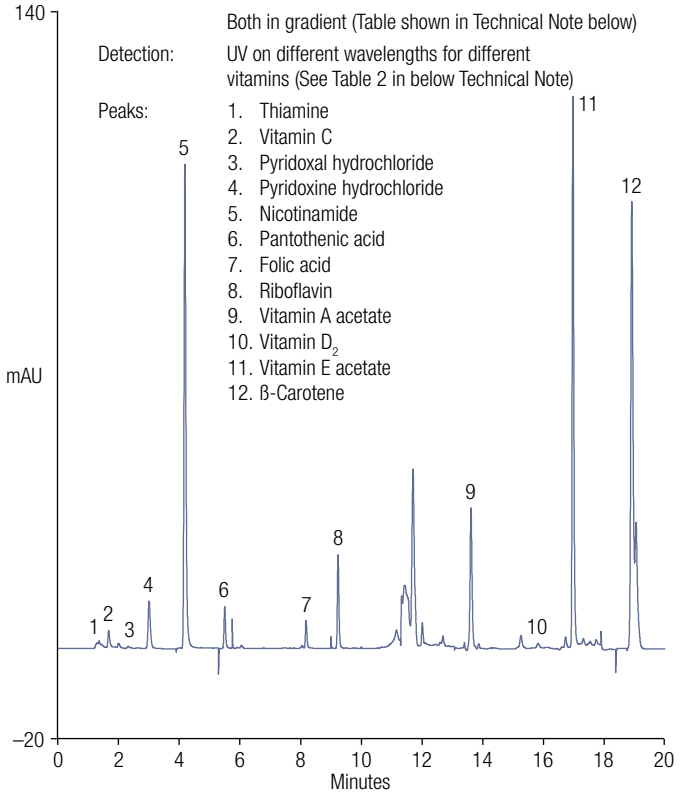


Figure 10-21. Chromatogram of chicken feed. There was a 1000-fold sample dilution for water-soluble vitamins, and a 100-fold dilution for fat-soluble vitamins.

Vitamin Mixtures

Determination of Water- and Fat-Soluble Vitamins in Nutritional Supplements

Column:	Acclaim PA2, 5 µm, 4.6 × 150 mm
Flow:	1.0 mL/min
Temperature:	25 °C
Injection Volume:	20 µL
Eluents:	A: CH_3CN
	B: 25 mM Phosphate buffer (dissolve about 3.4 g KH_2PO_4 in 1 L water, and adjust pH to 3.2 with H_3PO_4)
Gradient:	4–14 min, 0–35% A
	14.5–19 min, 80% A
	19.5–20 min, 0% A
Detection:	UV at 210 nm
Peaks:	1. Vitamin B_1
	2. Vitamin C (Separated alone under the same chromatographic conditions)
	3. Vitamin B_6
	4. Vitamin B_3
	5. Vitamin B_5
	6. Vitamin B_{12}
	7. Vitamin B_9
	8. Vitamin B_2

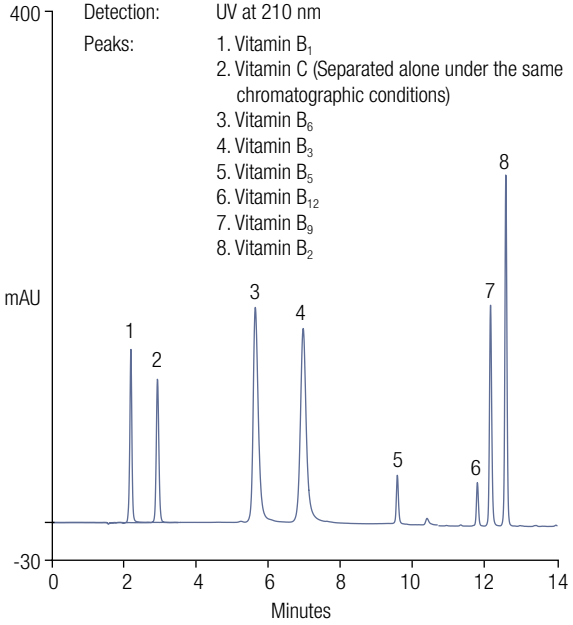


Figure 10-22. Separation of water-soluble vitamin standards.

Column:	Acclaim PA2, 5 µm, 4.6 × 150 mm
Flow:	1.0 mL/min
Temperature:	25 °C
Injection Volume:	20 µL
Eluents:	A: CH_3CN
	B: 25 mM Phosphate buffer (dissolve about 3.4 g KH_2PO_4 in 1 L water, and adjust pH to 3.2 with H_3PO_4)
Gradient:	4–14 min, 0–35% A
	14.5–19 min, 80% A
	19.5–20 min, 0% A
Detection:	UV at 210 nm
Samples:	A: Sample Brand 1
	B: Spiked sample Brand 1
Peaks:	1. Vitamin B_1
	2. Vitamin C
	3. Vitamin B_6
	4. Vitamin B_3
	5. Vitamin B_5
	6. Vitamin B_{12}
	7. Vitamin B_9
	8. Vitamin B_2

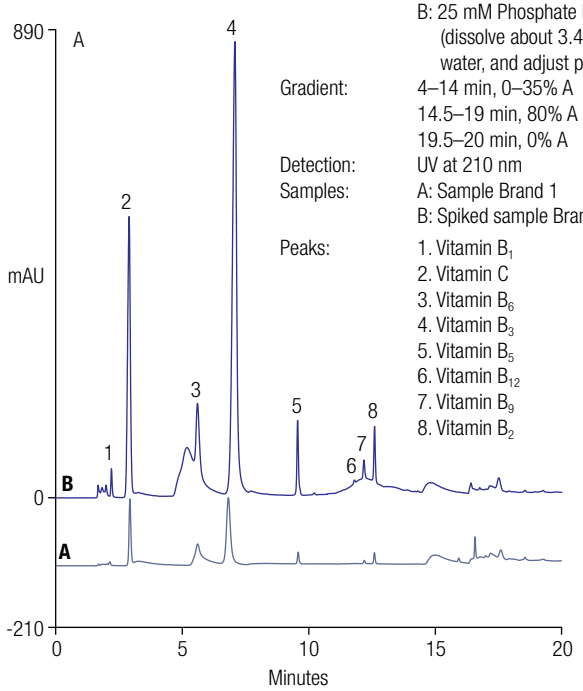


Figure 10-23. Separation of water-soluble vitamins in a supplement.

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Vitamin Mixtures

Column:	Acclaim C18, 5 µm, 4.6 × 150 mm
Flow:	1.0 mL/min
Temperature:	25 °C
Injection Volume:	20 µL
Eluents:	A: CH_3OH-CH_3CN (8:2, v/v) B: Methyl *tert*-butyl ether (MTBE)
Gradient:	3–4.5 min, 95–80% A 5–10 min, 65% A 10.1–15 min, 95% A
Detection:	Wavelength-switching absorbance at 265, 325, and 450 nm
Switching Time:	0.0 min, 325 nm 4.2 min, 265 nm 9.0 min, 450 nm
Peaks:	1. Vitamin A 2. Vitamin A acetate 3. Vitamin D_2 4. Vitamin D_3 5. Vitamin E acetate 6. Vitamin K_1 7. β-carotene

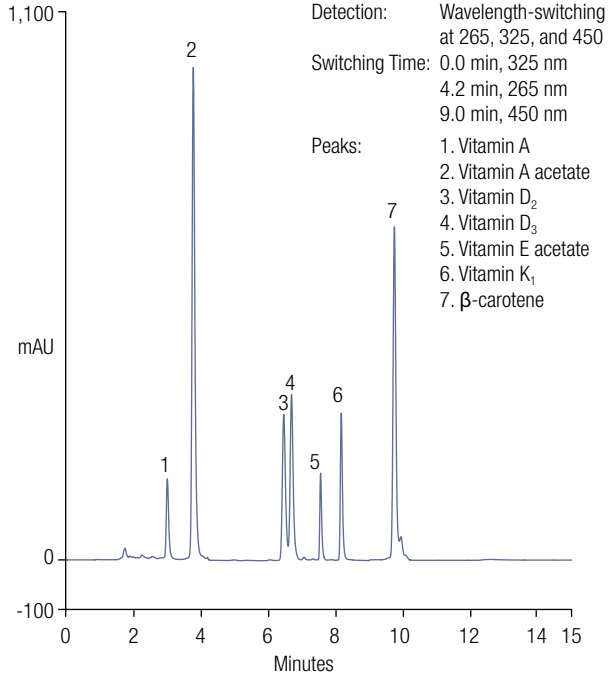

Figure 10-24. Separation of fat-soluble vitamin standards.

Column:	Acclaim C18, 5 µm, 4.6 × 150 mm
Flow:	1.0 mL/min
Temperature:	25 °C
Injection Volume:	20 µL
Eluents:	A: CH_3OH-CH_3CN (8:2, v/v) B: Methyl *tert*-butyl ether (MTBE)
Gradient:	3–4.5 min, 95–80% A 5–10 min, 65% A 10.1–15 min, 95% A
Detection:	Wavelength-switching absorbance at 265, 325, and 450 nm
Switching Time:	0.0 min, 325 nm 4.2 min, 265 nm 9.0 min, 450 nm
Samples:	A: Sample Brand 1 B: Spiked sample Brand 1
Peaks:	1. Vitamin A 2. Vitamin A acetate 3. Vitamin D_2 4. Vitamin D_3 5. Vitamin E acetate 6. Vitamin K_1 7. β-carotene

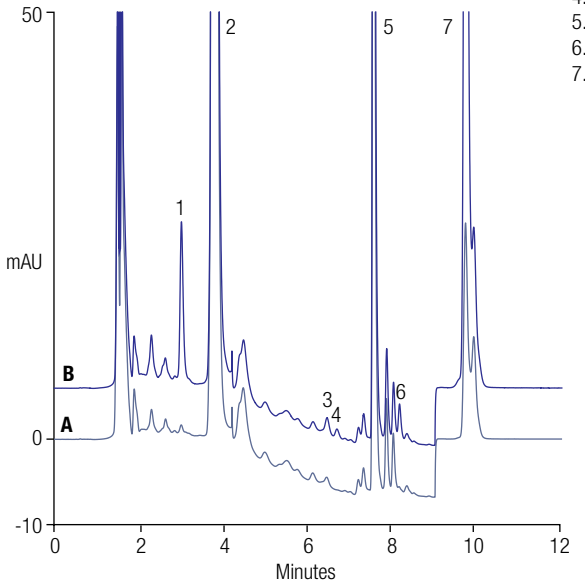

Figure 10-25. Separation of fat-soluble vitamins in a supplement.

Thermo SCIENTIFIC

Vitamin Mixtures

Samples: A: Water-soluble vitamin standards
B: Fat-soluble vitamin standards
Temperature: 25 °C
Injection Volume: 5 µL

For water-soluble vitamins:
Column: Acclaim PA2, 3 µm, 3.0 × 150 mm,
Eluents: A: CH_3CN
B: 25 mM Phosphate buffer (dissolve about 3.4 g KH_2PO_4 in 1 L water, and adjust pH to 3.2 with H_3PO_4)
Gradient: 0.5–4.5 min, 0–45% A
4.5–5 min, 45–70% A
5–6 min, 70% A
Flow Rate: 0.9 mL/min
Detection: Wavelength-switching absorbance at:
0.0 min, 245 nm; 2.0 min, 260 nm; 3.4 min, 210 nm
3.8 min, 280 nm

Peaks:
1. Vitamin B_1
2. Vitamin C
3. Vitamin B_6
4. Vitamin B_3
5. Vitamin B_5
6. Vitamin B_{12}
7. Vitamin B_9
8. Vitamin B_2

For fat-soluble vitamins:
Column: Acclaim C18, 3 µm, 4.6 × 150 mm
Eluents: A: CH_3OH-CH_3CN (8:2, v/v)
B: Methyl *tert*-butyl ether (MTBE)
Gradient: 1.25–2.0 min, 95–80% A
2.0–2.25 min, 80–65% A
4.5–4.6 min, 65–95% A
Flow Rate: 1.0 mL/min
Detection: Wavelength-switching absorbance at:
0.0 min, 325 nm; 2.0 min, 265 nm; 4.5 min, 450 nm

Peaks:
1. Vitamin A
2. Vitamin A acetate
3. Vitamin D_2
4. Vitamin D_3
5. Vitamin E acetate,
6. Vitamin K_1
7. β-carotene

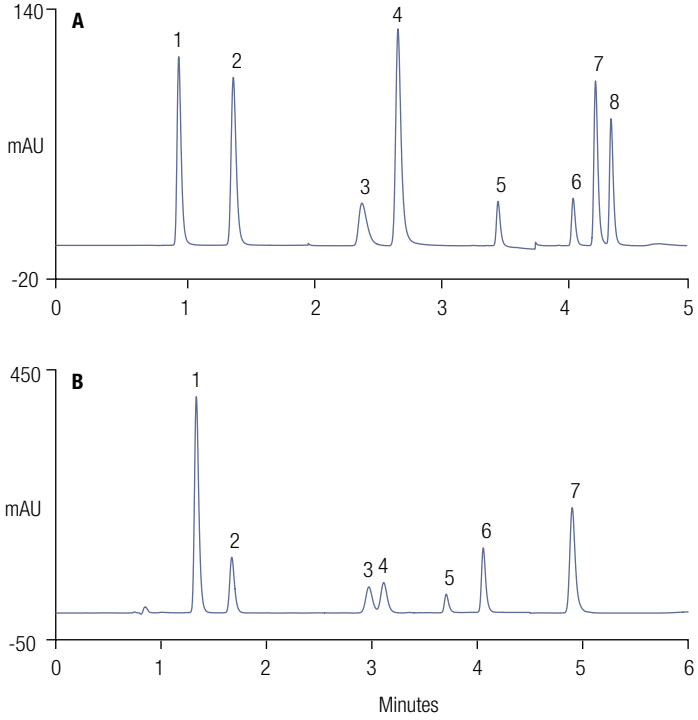

Figure 10-26. Improved throughput of water- and fat soluble vitamin analysis.

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Vitamin Mixtures

Global Measurement of Fat-Soluble Vitamins and Fat-Soluble Antioxidants

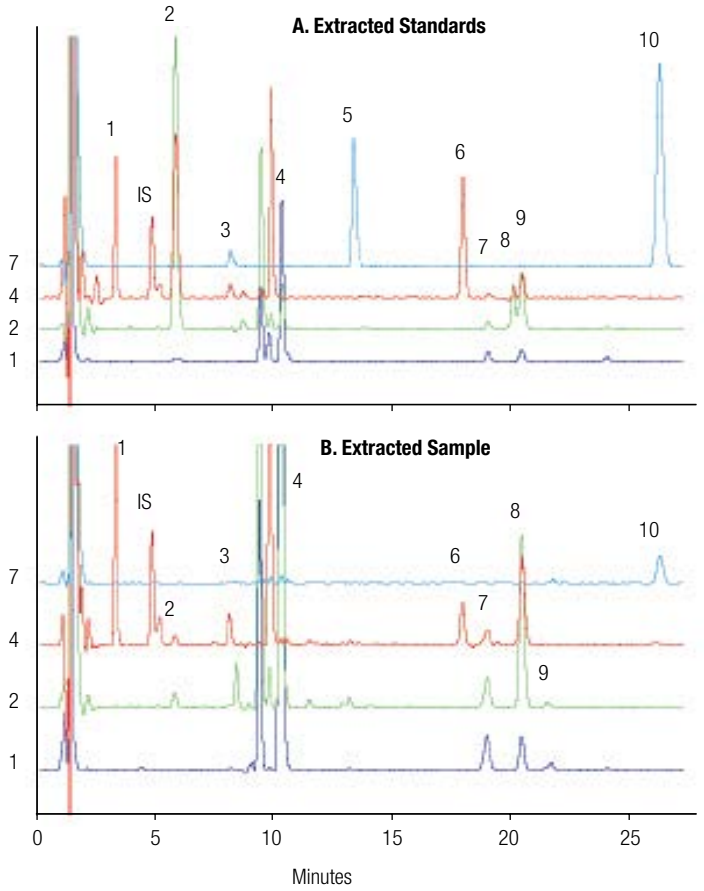
Fat-soluble vitamins (FSVs) and fat-soluble antioxidants (FSAs) play essential roles in a wide spectrum of biochemical and physiological processes. Vitamin E (tocopherol) along with other FSAs (e.g., carotenoids and coenzyme Q10 [CoQ10]) are purported to help mitigate the effects of oxidative stress that have been linked to numerous diseases, including cancer, neurodegeneration, and atherosclerosis. Some of these compounds are thought to exert their beneficial effects by acting as chain-breaking antioxidants, inhibiting lipid peroxidation of polyunsaturated fatty acids (PUFAs) contained within biological membranes, thereby preventing the formation of potentially cytotoxic and highly reactive aldehydes.

Although a number of FSVs and FSAs have been measured using HPLC-UV, this approach typically lacks the sensitivity and selectivity required to measure these compounds in biological samples. Electrochemical detection, however, is both sensitive and selective and makes use of the inherent redox activity of these compounds. The CoulArray Coulometric Array Detector – with its full gradient compatibility – uses an array of flow-through, highly efficient electrochemical sensors to generate qualitative voltammetric data to help identify analytes and resolve coeluting compounds. It is ideal for measuring analytes in food matrices, beverages, supplements, and biological tissues.

Vitamin Mixtures

Global FSV and FSA Method

Column:	MD150, 150 × 3 mm, 3 µM C18
Flow:	0.8 mL/min
Temperature:	37 °C
Mobile Phase:	A: Methanol: 0.2 M ammonium acetate, pH 4.4, (90:10) (v/v) B: Methanol: 1-propanol: 1.0 M ammonium acetate, pH 4.4, (78:20:2) (v/v/v)
Gradient:	Isocratic 0% B from 0 to 4 min. Linear increase of phase B from 0 to 80% from 4 to 15 min. Linear increase of phase B from 80 to 100% from 15 to 25 min. Isocratic 100% phase B from 25 to 32 min. Linear decrease of phase B from 100 to 0% from 32 to 35 min.
Potentials:	200, 400, 500, 700, 800, -1000, 200, 500 mV vs Pd
Detection:	CoulArray
Peaks:	1. Retinol 2. Lutein 3. γ-Tocopherol 4. α-Tocopherol 5. Vitamin K_1 6. Retinyl Palmitate (all *trans*) 7. Lycopene 8. α-Carotene 9. β-Carotene 10. Coenzyme Q10 IS. (Internal Standard) Retinyl Acetate



Only some channels (Ch) are shown for clarity. Ch 1 = 200 mV; Ch 2 = 400 mV; Ch 4 = 700 mV; Ch 7 reoxidation at 200 mV following reduction on Ch 6 at -1000 mV.

Figure 10-27. Global fat-soluble vitamin and fat-soluble antioxidant method.

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Vitamin Mixtures

Multivitamin Analysis

Determination of lipid-soluble vitamins in food supplements and fortified products is important for product labeling, nutritional research, product development, and quality control. Many factors complicate their measurement including the existence of multiple forms, compound instability, matrix complexity, and the relatively concentrations levels of certain analytes. HPLC-coulometric array detection simplifies multi-component lipid-soluble nutrient analyses.

Column:	Thermo Scientific™ BetaBasic™ C18, 5µ, 250 × 4.6 mm i.d.
Mobile Phase:	A: Acetonitrile: water, 90: 10 (v/v) containing 20 mM $NaClO_4$ and 5.0mM $HClO_4$ B: Acetonitrile: 1-propanol, 65: 35 (v/v) containing 20 mM $NaClO_4$ and 10 mM $HClO_4$
Gradient:	30 min; 20 min linear gradient from 10 to 100% B followed by a 5 min hold at 100% B before returning to initial conditions for 5 min
Flow:	1.5 mL/min
Column Temp.:	32 °C
Detection:	CoulArray
Detector Potentials:	-700, 100, 250, 400, 550, 750, 800, 850 (mV vs. Pd)

Peaks:
1. Retinol
2. Retinyl acetate
3. Vitamin D_3
4. γ-tocopherol
5. α-tocopherol
6. α-tocopheryl acetate
7. Vitamin K_1
8. β-tocopheryl acetate

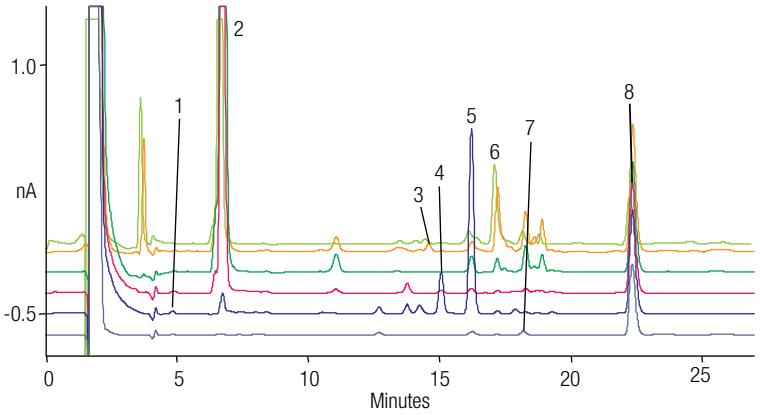

Figure 10-28. Extracted multivitamin tablet.

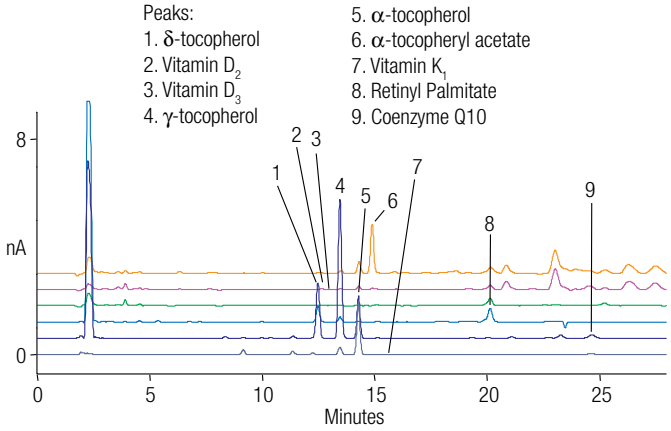

Figure 10-25. Extracted infant formula. See Figure 10-24 for conditions.

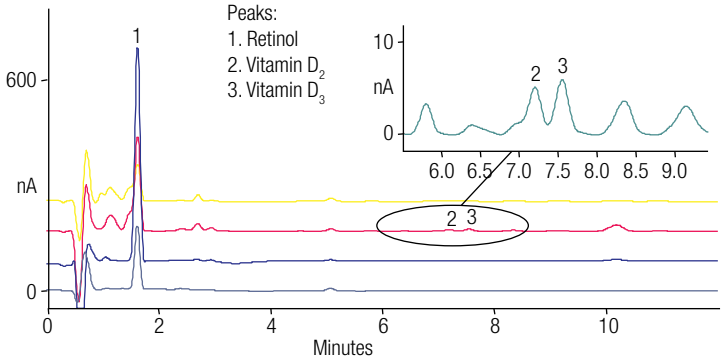

Figure 10-29. Detection of Vitamins D_2 and D_3 in saponified milk extract. See Figure 10-24 for conditions.

Download Application Note 1110: Simultaneous Measurement of Vitamins A, D, E, K, along with CoQ10 and Carotenoids, in Multivitamin Tablets, Infant Formula and Milk

Chapter 10: Vitamins and Antioxidants

Antioxidants

Low molecular weight antioxidants are protective molecules that prevent or hinder oxidative damage to key biomolecules, such as DNA, proteins, and membrane lipids. As discussed earlier, some vitamins (e.g., A, C, and E) can act as antioxidants. This section, however, discusses the measurement of some non-essential antioxidants obtained from the diet, through supplementation or from *in vivo* synthesis.

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Antioxidants

Carotenoid Isomers

Carotenoids are responsible for the characteristic colors of many fruits and vegetables, including tomatoes, squash, yams, carrots and chilies. In yellow tomatoes, lycopene (red) is converted first to carotenes (orange) by cyclase enzymes, then to lutein (yellow) by hydroxylase enzymes. In red tomatoes, the expression of the cyclase and hydroxylase enzymes is reduced, leading to an accumulation of the red lycopene. Various cultivars express these enzymes in characteristic ways, leading to a variety of red, orange, yellow, and patterned fruits. The carotene content also affects the nutritional value of the crop, the principal ones of interest being lycopene, α- and β-carotene, and lutein. Examples show carotenoid separations on an Acclaim C30 and an Acclaim PA column. The ability to measure carotenoids in plasma is also shown.

Much of the interest in dietary carotenoids, exclusive of their pro-vitamin A activity, is related to their possible actions as preventive agents in diseases associated with oxidative stress. These electron-rich compounds can act as antioxidants *in vitro* and their possible role of protection from reactive oxygen and nitrogen species *in vivo* has received much attention.

Column:	Acclaim C30, 3 µm, 3.0 × 150 mm				
LC System:	UltiMate 3000 RSLC system				
Mobile Phases:	A) Acetonitrile				
	B) Methanol:Ethyl acetate 1:1 (v/v)				
	C) 10 mM Formic acid in water				
Gradient Times (min):	-8.0	0.0	1.0	21.0	25.0
%A	95.0	95.0	95.0	54.5	54.5
%B	4.5	4.5	4.5	45.0	45.0
%C	0.5	0.5	0.5	0.5	0.5
Flow:	0.64 mL/min				
Temperature:	30 °C				
Injection Volume:	8 µL				
Detection:	DAD (260-800 nm); traces at 450 nm shown				
Sample Preparation:	See D. B. Rodriguez-Amaya and M. Kimura, "HarvestPlus Handbook for Carotenoid Analysis", International Food Policy Research Institute, 2004.				
Samples:	A. Red tomato, 0.20 g/mL				
	B. Yellow tomato, 5.6 g/mL				
Peaks:	1. Lutein				
	2. β-Carotene				
	3. Lycopene				

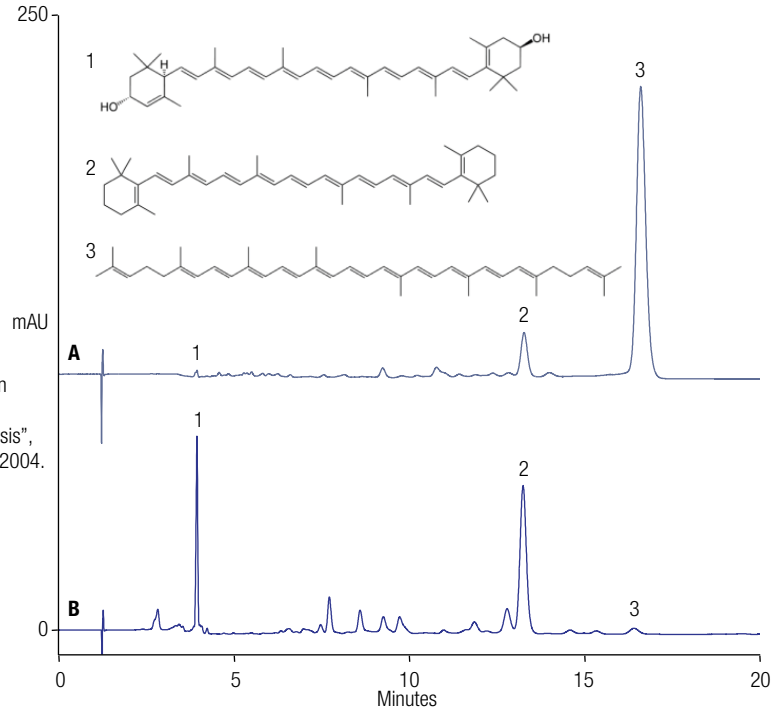

Figure 10-30. Carotenoid profiles of tomato cultivars using the Acclaim C30 column.

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Antioxidants

Column:	Acclaim PA, 3 µm, 4.6 × 150 mm
Flow:	1.25 mL/min
Temperature:	30 °C
Injection Volume:	25 µL
Mobile Phase:	A: Water B: 54:44:2 methanol:acetonitrile:isopropanol
Gradient:	Time 0 8.0 8.1 25 %A 5 5 0 0 %B 95 95 100 100
Detection:	UVD 340U diode array, 450 nm, and spectra 200–595 nm
Sample:	Extract of bovine serum, fortified with lycopene equivalent to 300 ng/mL
Peaks:	1. Unidentified carotenoid 2. *trans*-lycopene 3. *trans*--β-carotene 4. *cis*-β-carotene

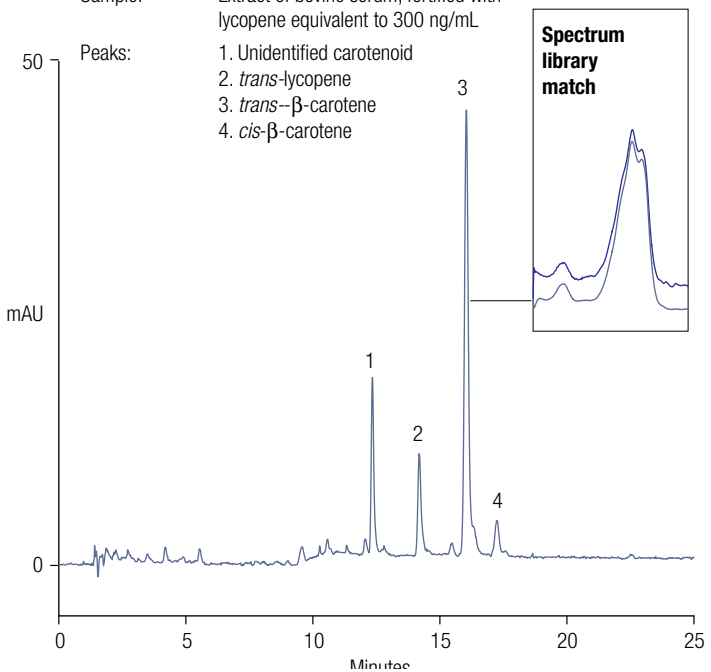

Figure 10-31. Carotenoids in serum using the Acclaim PA column.

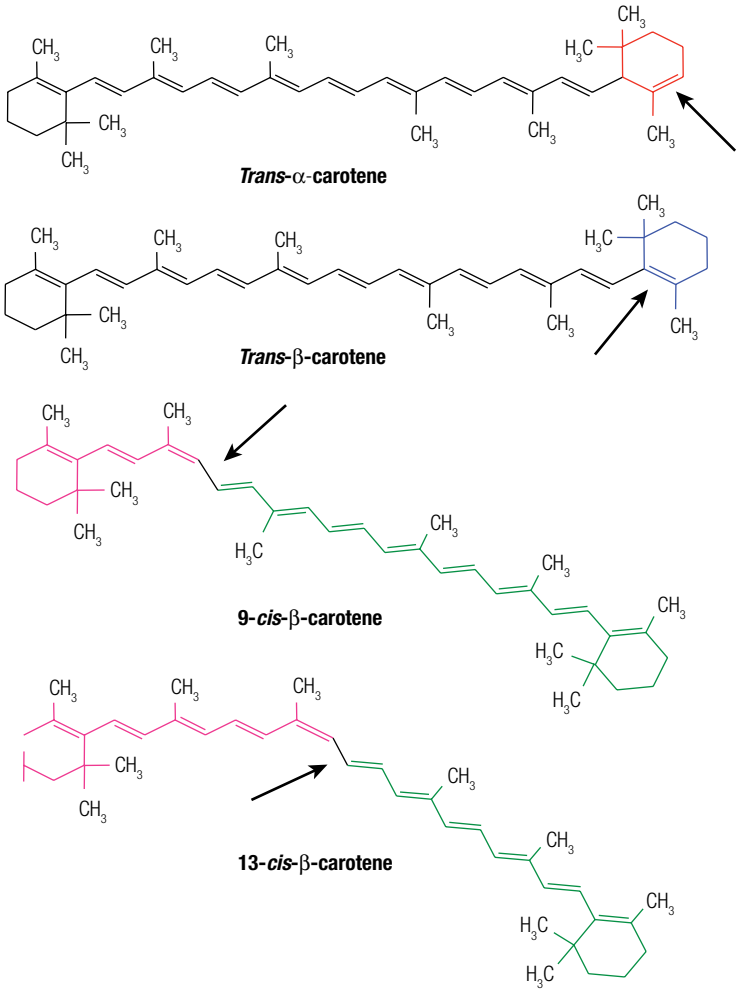

Figure 10-32. Dietary carotenoids can each be found as a variable mixture of geometric and positional isomers (e.g., all trans, cis-9-, and cis-13). These isomers may occur naturally or can be formed during processing and show a variety of biological properties and chemical activities.

Antioxidants

Column:	C30, 4.6 × 250, 5 µm
Flow:	1 mL/min
Temperature:	28 °C
Injection Volume:	10 µL
Mobile Phase:	1 M ammonium acetate, pH 4.0: methyl-tert-butyl ether: methanol, 2:35:63 (v/v/v)
Electrochemical Detection:	CoulArray
Potentials:	+100 to +520 mV (vs Pd) in 60 mV increments
UV Detector Wavelength:	450 nm

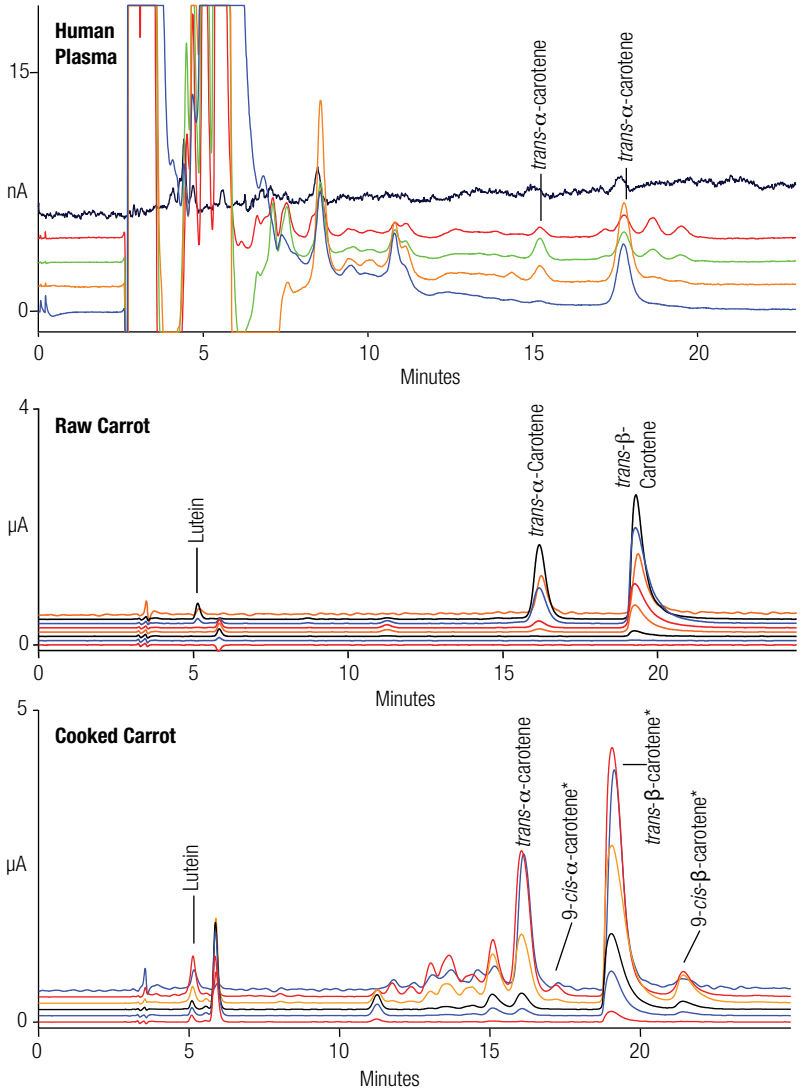

Figure 10-33. Determination of carotenoid isomers in human plasma, raw, and cooked carrot.

Antioxidants

Lipoic Acid

Acetylcarnitine functions as part of the system that transports fatty acids into the mitochondria for energy metabolism. While it is biosynthesized in the liver, sometimes dietary supplementation is beneficial. Lipoic acid is essential for aerobic metabolism. Both acetylcarnitine and lipoic acid cross the blood-brain barrier, and are believed to be neuroprotective.

Acetyl carnitine is poorly retained on RP-HPLC columns due to its hydrophilic nature. The Acclaim Trinity P1 provides cation-exchange, anion-exchange, and reversed-phase retention mechanisms, and thus is ideal for retaining charged analytes. As shown here, acetyl carnitine elutes as a cation under a low pH and low ionic strength condition on the Acclaim Trinity P1 column. Because lipoic acid is retained mostly by a RP mechanism, it elutes after acetylcarnitine with higher acetonitrile.

Column:	Acclaim Trinity P1, 3 µm
Flow:	0.50 mL/min
Temperature:	30 °C
Injection Volume:	4.0 µL
Dimension:	3.0 × 50 mm
HPLC System:	UltiMate 3000 RS
Mobile Phase:	A: 3 g Monobasic sodium phosphate (25 mmol), 22 mg tetrasodium pyrophosphate decahydrate (0.5 mmol) + 270 µL 85% phosphoric acid (4 mmol) + 196 g acetonitrile + 750 g water B: 196 g Acetonitrile + 750 g water
Gradient Times (min):	-6.0 0.0 2.5 2.6 7.0 7.1
%A:	20 20 20 100 100 20
%B:	80 80 80 0 0 80
Detection:	UV at 210 nm
Sample:	Dissolve one tablet containing 400 mg acetylcarnitine and 200 mg lipoic acid in 400 mL water with 100 mg sodium bicarbonate in a sonic bath; filter
Peaks:	1. Carnitine 2. Lipoic acid

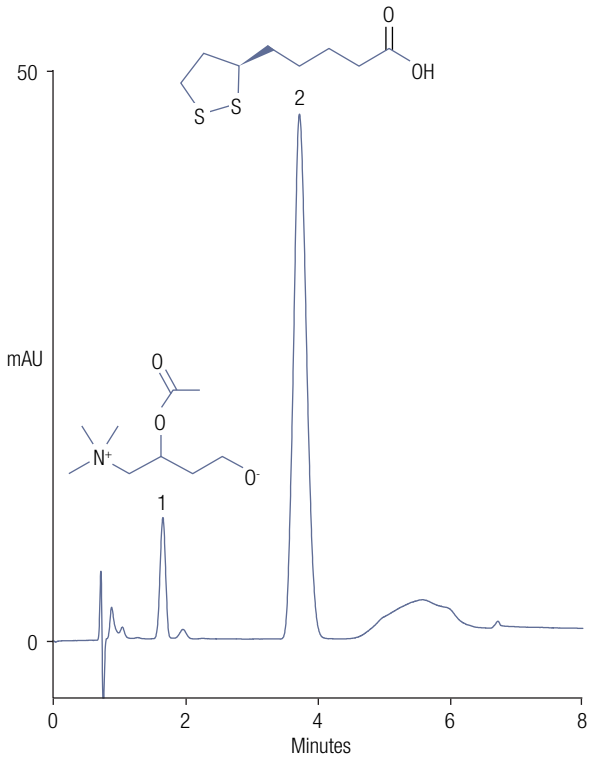

Figure 10-34. Determination of acetylcarnitine and lipoic acid in a nutritional supplement using the Acclaim Trinity P1 column.

Antioxidants

Lipoic Acid

α-Lipoic acid (6,8-thioctic acid, 1,2-dithiolane-3-pentanoic acid, or 1,2-dithiolane-3-valeric acid) is a water insoluble compound found *in vivo,* and is consumed in the form of a supplement as an antioxidant. α-Lipoic acid supplementation is being advocated in the treatment of AIDS, Chaga, diabetes, heavy-metal poisoning, ischemia-reperfusion injury, liver diseases (e.g., mushroom poisoning and alcoholic liver disease), neurodegenerative disorders, and radiation injury.

Column:	ODS 2, 4.6 × 150 mm, 5 µm
Flow:	1.0 mL/min
Temperature:	35 °C
Injection Volume:	20 µL
Mobile Phase:	Water-Acetonitrile-1.0 M Sodium Phosphate pH 3.5; 60:35:5 (v/v/v)
Detection:	CoulArray
Applied Potentials:	400, 460, 520, 580, 700, 720 and 820 (mV vs. Pd reference)
Peak:	1. Lipoic acid

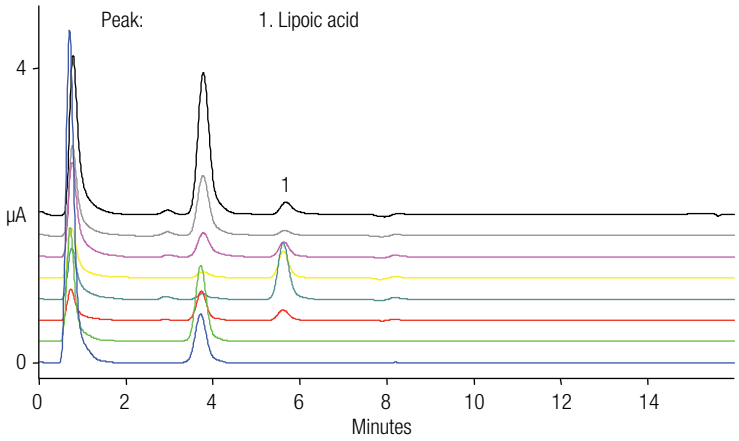

Figure 10-35. HPLC-coulometric electrochemical array chromatogram of lipoic acid in a multi-vitamin supplement.

Trivia Question

Q: Do foods and beverages that are high in levels of antioxidant flavonoids act as antioxidants in the body?

A: This is a very complex question, but it is highly unlikely that they do. This is not to say that they do not offer health benefits, just not through their antioxidant content (or capacity). For example, flavonoids undergo extensive gut metabolism, conjugation and clearance, and usually very little enters the circulatory system. Frequently, research studies use unrealistically high levels, so that results are very difficult to interpret. Finally, it is often difficult to measure changes in circulating and tissue levels of flavonoids following food and beverage consumption.

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Antioxidants

Tocopherols and Tocotrienols

Tocotrienols are chemically similar to tocopherols except the phytol side chains contain 3 double bonds in their structure. Although the antioxidant activity of tocotrienols is higher than that of tocopherols, tocotrienols have a lower bioavailability after oral ingestion.

The vitamin E component of palm oil provides a rich source of tocotrienols. The use of gradient reversed-phase HPLC with coulometric electrochemical array detection enables the simultaneous measurement of both tocotrienols and tocopherols at fmole concentrations.

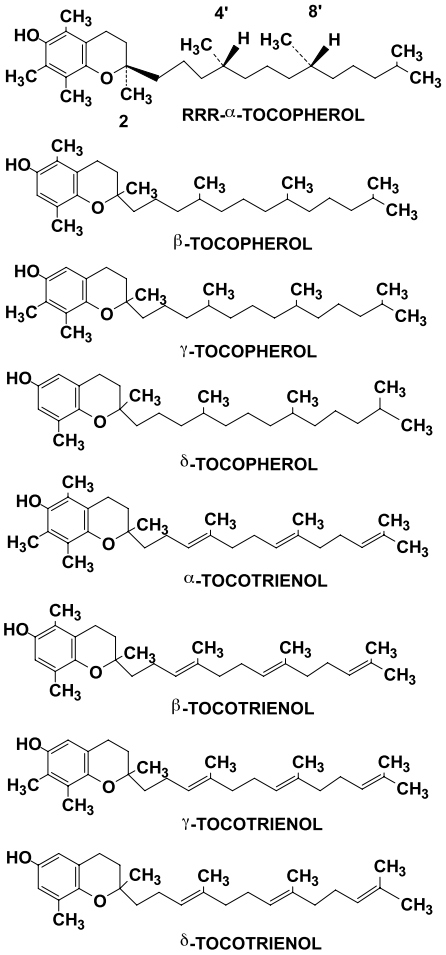


Figure 10-36. Structures of the various tocopherol and tocotrienol vitamers.

Antioxidants

Column:	Hypersil BDS, 150 × 3.0 mm, 3 µm, C18
Flow:	0.6 mL/min
Temperature:	32 °C
Injection Volume:	10 µL
Mobile Phase:	A: Acetonitrile: water, 90:10 (v/v) containing 20 mM sodium perchlorate and 5 mM perchloric acid B: Acetonitrile: 1-propanol, 65:35 (v/v) containing 20 mM sodium perchlorate and 10 mM perchloric acid
Gradient:	Isocratic 10% B from 0 to 4 min. Linear increase of phase B from 10 to 100% B for 21 min. Isocratic 100% B for 9 min before returning to initial conditions for 5 min. Total run time was 40 min.
Detection:	CoulArray
Potentials:	-700, 0, 75, 150, 225, 300, 375, and 450 mV vs Pd

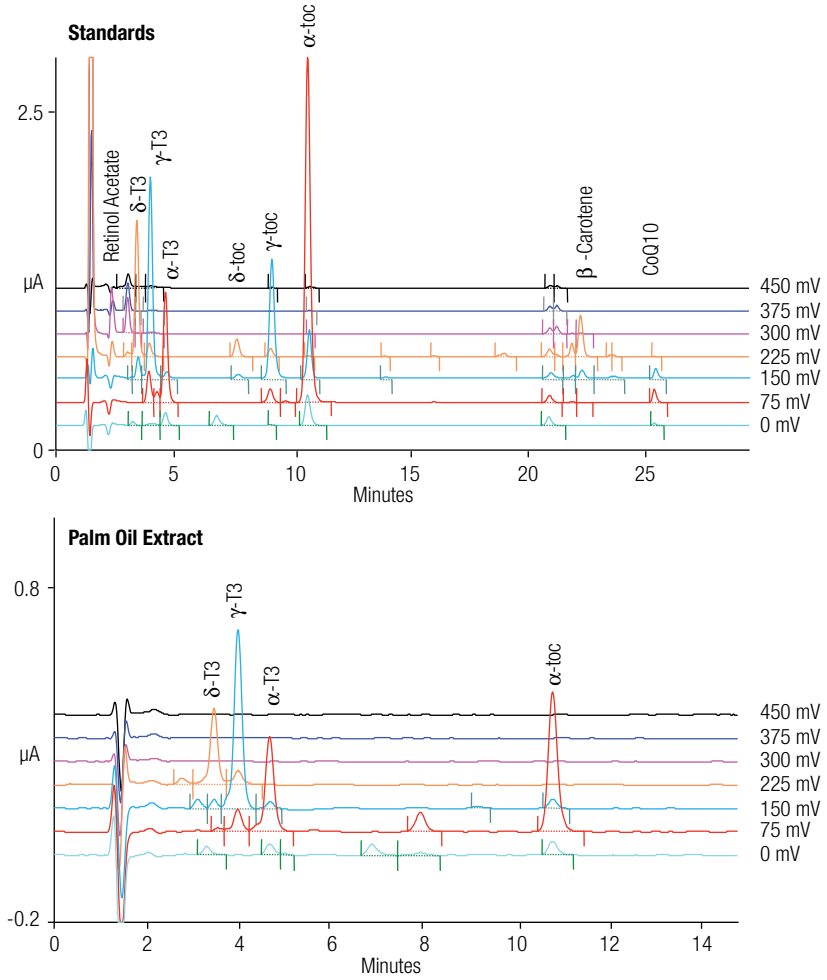


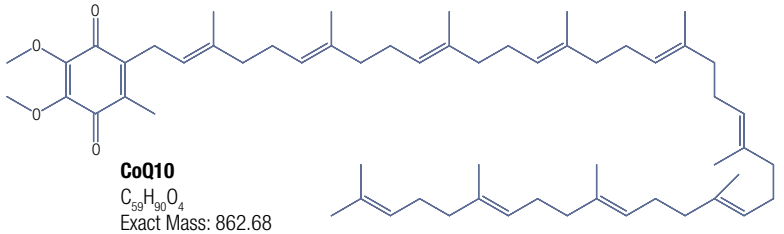
Figure 10-37. Gradient HPLC with CoulArray detection of tocotrienols (T) and tocopherols (toc) in palm oil extract.

Antioxidants

Ubiquinone

Coenzyme Q10 (2,3 dimethoxy-5 methyl-6-decaprenyl benzoquinone) is a fat-soluble, vitamin-like quinone commonly known as ubiquinone, CoQ, or vitamin Q10. Coenzyme Q10 is used by cells to produce energy needed for cell growth and maintenance. Coenzyme Q10 is a compound that is made naturally in the body and is found in most body tissues. The highest amounts of CoQ10 are found in the heart, liver, kidneys, and pancreas while the lowest amounts are found in the lungs. The tissue levels of Coenzyme Q10 decrease as people age.

Coenzyme Q10 is a powerful antioxidant that acts as an electron shuttle between flavoproteins and cytochromes in the electrontransport chain. It is the only electron shuttle that is not covalently bonded or tightly bound to a protein. Coenzyme Q10 is a naturally occurring antioxidant. As a dietary supplement, it is used to prevent or to treat congestive heart failure, to delay the onset of Parkinson's syndrome, and to prevent or to treat certain forms of cancer. Coenzyme Q10 is easily separated on the Acclaim PA II column.



CoQ10
$C_{59}H_{90}O_4$
Exact Mass: 862.68
Mol. Wt.: 863.68
m/e: 862.68 (100.0%), 863.69 (67.1%), 864.69 (23.0%), 865.69 (5.0%)
C, 82.08; H, 10.51; O, 7.41

Figure 10-38. Chemical structure of coenxyme Q10.

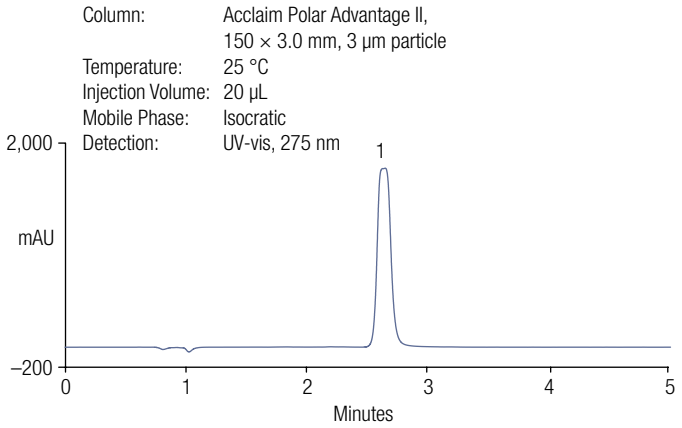


Figure 10-39. CoQ10 stock standard.

Did You Know?

The synthesis of ubiquinone in the body may be affected by statins used to control cholesterol levels (as the drug inhibits an enzyme involved in both cholesterol and ubiquinone synthesis).

Antioxidants

Ubiquinone Speciation

Ubinquinone (CoQ10) is a ubiquitous lipid-soluble, redox active component, found in most cell membranes. It exists in both oxidized (quinone) and reduced (quinol) forms. The predominant form found in humans is CoQ10 (some CoQ9). Supplements can contain either ubiquinone or the more costly ubiquinol. Primary deficiency results in a variety of clinical conditions: encephalomyopathy, infantile multi-systemic disease, cerebellar ataxia, and leigh syndrome. Deficiencies can result when taking cholesterol lowering drugs (e.g., statins) and some beta-blockers. HPLC with coulometric electrochemical detection can be used to measure both oxidized and reduced forms of CoQ10 and CoQ9 in plasma and supplements.

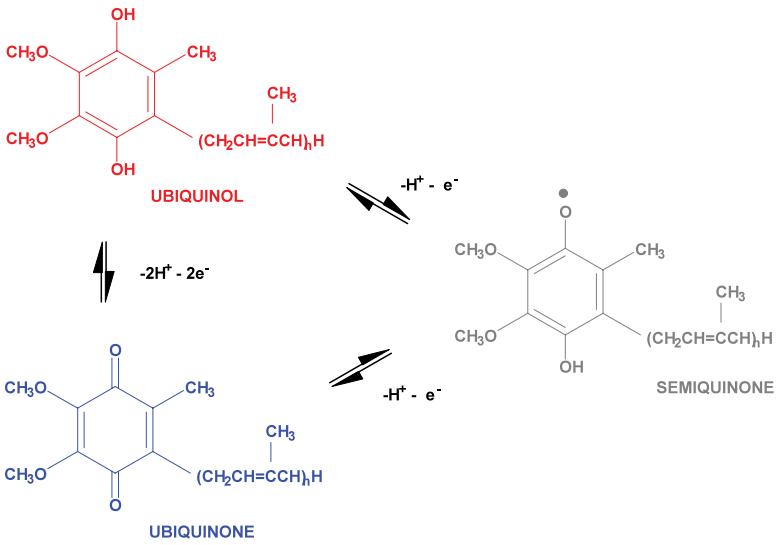


Figure 10-40. Chemical structure of ubinquinone and its oxidized and reduced forms, quinone, and quinol, respectively.

Column:	C18, 4.6 × 50 mm, 3 µm
Flow:	1.0 mL/min
Temperature:	32 °C
Injection Volume:	50 µL (tray at 4 °C)
Mobile Phase:	Methanol: 1-Propanol: 1.0 M Ammonium Acetate, pH 4.4: (78:20:2) (v/v/v)
Detection:	CoulArray
Applied potentials:	+700, -700, +500 mV vs Pd

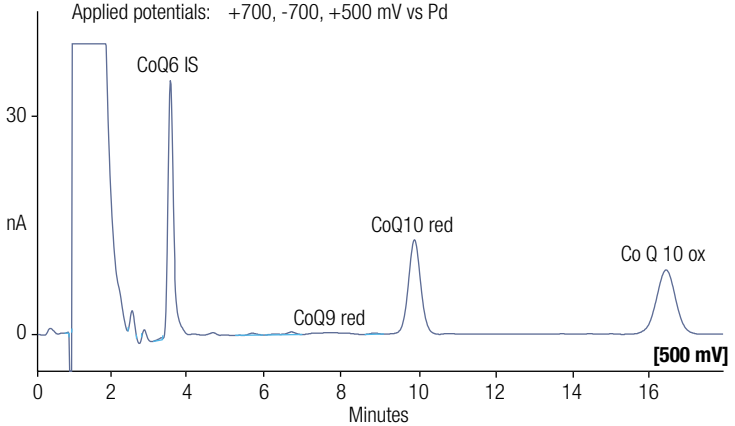
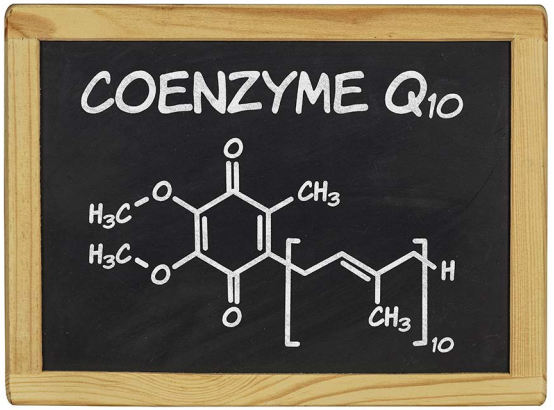


Figure 10-41. Analysis of extracted human plasma (CoQ6 used as an internal standard)



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A combination of aspirin and γ-tocopherol is superior to that of aspirin and α-tocopherol in anti-inflammatory action and attenuation of aspirin-induced adverse effects	Jiang, Q.; Moreland, M.; Ames, B. N.; Yin, X.	*J. Nutr. Biochem. 20 (11),* 894–900	2009 Nov
HPLC analysis of rosmarinic acid in feed enriched with aerial parts of *Prunella vulgaris* and its metabolites in pig plasma using dual-channel coulometric detection	Jirovský, D.; Kosina, P.; Myslínová, M.; Stýskala, J.; Ulrichová, J.; Simánek V.	*J. Agric. Food Chem. 55 (19),* 7631–7637	2007 Sep 19
Molar absorptivities and reducing capacity of pyranoanthocyanins and other anthocyanins	Jordheim, M.; Aaby, K.; Fossen, T.; Skrede, G.; Andersen, Ø. M.	*J. Agric. Food Chem. 55 (26),* 10591–10598	2007 Dec 26
Sensitive electrochemical detection method for alpha-acids, beta-acids and xanthohumol in hops (*Humulus lupulus L.*)	Kac, J.; Vovk, T.	*J. Chromatogr., B: Anal. Technol. Biomed. Life Sci. 850 (1–2),* 531–537	2007 May 1
Determination of phenolic compounds and hydroxymethylfurfural in meads using high performance liquid chromatography with coulometric-array and UV detection	Kahoun, D.; Rezková, S.; Veskrnová, K.; Královský, J.; Holcapek, M.	*J. Chromatogr., A 1202 (1),* 19–33	2008 Aug 15
Analysis of terpene lactones in a Ginkgo leaf extract by high-performance liquid chromatography using charged aerosol detection	Kakigi, Y.; Mochizuki, N.; Icho, T.; Hakamatsuka, T.; Goda, Y.	*Biosci., Biotechnol., Biochem. 74 (3),* 590–594	2010
Linear aglycones are the substrates for glycosyltransferase DesVII in methymycin biosynthesis: analysis and implications	Kao, C.; Borisova, S.; Kim, H.; Liu, H.	*J. Am. Chem. Soc. 128 (17),* 5606–5607	2006 May 3

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Antioxidant-rich food intakes and their association with blood total antioxidant status and vitamin C and E levels in community-dwelling seniors from the Quebec longitudinal study NuAge	Khalil, A.; Gaudreau, P.; Cherki, M.; Wagner, R.; Tessier, D. M.; Fulop, T.; Shatenstein, B.	*Exp. Gerontol. 46 (6),* 475–481	2011 Jun
Certification of a pure reference material for the ginsenoside Rg1	Kim, D.; Chang, J.; Sohn, H.; Cho, B.; Ko, S.; Nho, K.; Jang, D.; Lee, S.	*Accredit. Qual. Assur. 15 (2),* 81–87	2009 Sep
Optimization of pressurized liquid extraction for spicatoside A in *Liriope platyphylla*	Kim, S. H.; Kim, H. K.; Yang, E. S.; Lee, K. Y.; Kim, S. D.; Kim, Y. C.; Sung, S. H.	*Sep. Purif. Technol. 71 (2),* 168–172	2010
Production of surfactin and iturin by *Bacillus licheniformis* N1 responsible for plant disease control activity	Kong, H. G.; Kim, J. C.; Choi, G. J.; Lee, K. Y.; Kim, H. J.; Hwang, E. C.; Moon, B. J.; Lee, S. W.	*Plant Pathol. J. 26 (2),* 170–177	2010
Transepithelial transport of microbial metabolites of quercetin in intestinal Caco-2 cell monolayers	Konishi, Y.	*J. Agric. Food Chem. 53 (3),* 601–607	2005 Feb 9
Absorption and bioavailability of artepillin C in rats after oral administration	Konishi, Y.; Hitomi, Y.; Yoshida, M.; Yoshioka, E.	*J. Agric. Food Chem. 53 (26),* 9928–9933	2005 Dec 28
Pharmacokinetic study of caffeic and rosmarinic acids in rats after oral administration	Konishi, Y.; Hitomi, Y.; Yoshida, M.; Yoshioka, E.	*J. Agric. Food Chem. 53 (12),* 4740–4746	2005 Jun 15
Intestinal absorption of *p*-coumaric and gallic acids in rats after oral administration	Konishi, Y.; Hitomi, Y.; Yoshioka, E.	*J. Agric. Food Chem. 52 (9),* 2527–2532	2004 May 5
Microbial metabolites of ingested caffeic acid are absorbed by the monocarboxylic acid transporter (MCT) in intestinal Caco-2 cell monolayers	Konishi, Y.; Kobayashi, S.	*J. Agric. Food Chem. 52 (21),* 6418–6424	2004 Oct 20
Transepithelial transport of rosmarinic acid in intestinal Caco-2 cell monolayers	Konishi, Y.; Kobayashi, S.	*Biosci., Biotechnol., Biochem. 69 (3),* 583–591	2005 Mar
Effects of various doses of selenite on stinging nettle (*Urtica dioica L.*)	Krystofova, O.; Adam, V.; Babula, P.; Zehnalek, J.; Beklova, M.; Havel, L.; Kizek, R.	*Int. J. Environ. Res. Public Health 7 (10),* 3804–3815	2010 Oct
Biofortified cassava increases β-carotene and vitamin A concentrations in the TAG-rich plasma layer of American women	La Frano, M. R.; Woodhouse, L. R.; Burnett, D. J.; Burri, B. J.	*Br. J. Nutr. 110 (2),* 310–320	2013 Jul 28
Chlorogenic acid is absorbed in its intact form in the stomach of rats	Lafay, S.; Gil-Izquierdo, A.; Manach, C.; Morand, C.; Besson, C.; Scalbert, A.	*J. Nutr. 136 (5),* 1192–1197	2006 May
Determination of 4-ethylcatechol in wine by high-performance liquid chromatography-coulometric electrochemical array detection	Larcher, R.; Nicolini, G.; Bertoldi, D.; Nardin, T.	*Anal. Chim. Acta 609 (2),* 235–240	2008 Feb 25
Determination of volatile phenols in wine using high-performance liquid chromatography with a coulometric array detector	Larcher, R.; Nicolini, G.; Puecher, C.; Bertoldi, D.; Moser, S.; Favaro, G.	*Anal. Chim. Acta 582 (1),* 55–60	2007 Jan 16

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Acute, quercetin-induced reductions in blood pressure in hypertensive individuals are not secondary to lower plasma angiotensin-converting enzyme activity or endothelin-1: nitric oxide	Larson, A.; Witman, M. A. H.; Guo, Y.; Ives, S.; Richardson, R. S.; Bruno, R. S.; Jalili, T.; Symons, J. D.	*Nutr. Res. (N. Y., NY, U.S.) 32 (8),* 557–564	2012 Aug
High-performance liquid chromatography method for the determination of folic acid in fortified food products	Lebiedzin´ska, A.; Da˛browska, M.; Szefer, P.; Marszałł M.	*Toxicol. Mech. Methods 18 (6),* 463–467	2008 Jul
Reversed-phase high-performance liquid chromatography method with coulometric electrochemical and ultraviolet detection for the quantification of vitamins B(1) (thiamine), B(6) (pyridoxamine, pyridoxal and pyridoxine) and B(12) in animal and plant foods	Lebiedzin´ska, A.; Marszałł, M. L.; Kuta, J.; Szefer, P.	*J. Chromatogr., A 1173 (1–2),* 71–80	2007 Nov 30
An improved method for the determination of green and black tea polyphenols in biomatrices by high-performance liquid chromatography with coulometric array detection	Lee, M. J.; Prabhu, S.; Meng, X.; Li, C.; Yang, C. S.	*Anal. Biochem. 279 (2),* 164–169	2000 Mar 15
Characterisation, extraction efficiency, stability and antioxidant activity of phytonutrients in *Angelica keiskei*	Li, L.; Aldini, G.; Carini, M.; Chen, C. Y. O.; Chun, H.; Cho, S.; Park, K.; Correa, C. R.; Russell, R. M.; Blumberg, J. B.; Yeum, K.	*Food Chem.* 115 (1), 227–232	2009 Jul
Vitamin A equivalence of the β-carotene in β-carotene-biofortified maize porridge consumed by women	Li, S.; Nugroho, A.; Rocheford, T.; White, W. S.	*Am. J. Clin. Nutr. 92 (5),* 1105–1112	2010 Nov
Phase IIa chemoprevention trial of green tea polyphenols in high-risk individuals of liver cancer: modulation of urinary excretion of green tea polyphenols and 8-hydroxydeoxyguanosine	Luo, H.; Tang, L.; Tang, M.; Billam, M.; Huang, T.; Yu, J.; Wei, Z.; Liang, Y.; Wang, K.; Zhang, Z. Q.; Zhang, L.; Wang, J. S.	*Carcinogenesis 27 (2),* 262–268	2006 Feb
Determination of four water-soluble compounds in *Salvia miltiorrhiza Bunge* by high-performance liquid chromatography with a coulometric electrode array system	Ma, L.; Zhang, X.; Guo, H.; Gan, Y.	*J. Chromatogr., B: Anal. Technol. Biomed. Life Sci. 833* (2), 260–263	2006 Apr 3
Effect of green tea powder (*Camellia sinensis L.* cv. Benifuuki) particle size on O-methylated EGCG absorption in rats, The Kakegawa Study	Maeda-Yamamoto, M.; Ema, K.; Tokuda, Y.; Monobe, M.; Tachibana, H.; Sameshima, Y.; Kuriyama, S.	*Cytotechnology 63 (2),* 171–179	2011 Mar
Supplementation of a γ-tocopherol-rich mixture of tocopherols in healthy men protects against vascular endothelial dysfunction induced by postprandial hyperglycemia	Mah, E.; Noh, S. K.; Ballard, K. D.; Park, H. J.; Volek, J. S.; Bruno, R. S.	*J. Nutr. Biochem. 24 (1),* 196–203	2013 Jan

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Mediterranean diet reduces endothelial damage and improves the regenerative capacity of endothelium	Marin, C.; Ramirez, R.; Delgado-Lista, J.; Yubero-Serrano, E. M.; Perez-Martinez, P.; Carracedo, J.; Garcia-Rios, A.; Rodriguez. F.; Gutierrez-Mariscal, F. M.; Gomez, P.; Perez-Jimenez, F.; Lopez-Miranda, J.	*Am. J. Clin. Nutr. 93 (2),* 267–274	2011 Feb
Photodiode array (PDA) and other detection methods in HPLC of plant metabolites	Markowski, W.; Waksmundzka-Hajnos, M.	Chapter 13 in *High Performance Liquid Chromatography in Phytochemical Analysis,* Chromatographic Science Series, Markowski, W., Sherma, J., Eds.; Taylor & Francis Group, LLC: Boca Raton, FL; 331–350	2010 Nov
Determination of water-soluble vitamins in infant milk and dietary supplement using a liquid chromatography on-line coupled to a corona-charged aerosol detector	Márquez-Sillero, I.; Cárdenas, S.; Valcárcel, M.	*J. Chromatogr., A. 1313C,* 253–258	2013 Oct 25
Sensitive high-performance liquid chromatographic method using coulometric electrode array detection for measurement of phytoestrogens in dried blood spots	Melby, M. K.; Watanabe, S.; Whitten, P. L.; Worthman, C. M.	*J. Chromatogr., B: Anal. Technol. Biomed. Life Sci. 826 (1–2),* 81–90	2005 Nov 5
Phenolic acids from beer are absorbed and extensively metabolized in humans	Nardini, M.; Natella, F.; Scaccini, C.; Ghiselli, A.	*J. Nutr. Biochem. 17 (1),* 14–22	2006 Jan
High-performance liquid chromatography analysis of plant saponins: An update 2005-2010	Negi, J. S.; Singh, P.; Pant, G. J.; Rawat, M. S.	*Pharmacogn. Rev. 5 (10),* 155–158	2011 Jul
Physicochemical effect of pH and antioxidants on mono- and triglutamate forms of 5-methyltetrahydrofolate, and evaluation of vitamin stability in human gastric juice: Implications for folate bioavailability	Ng, X.; Lucock, M.; Veysey, M.	*Food Chem. 106 (1),* 200–210	2008 Jan
Practical preparation of lacto-*N*-biose I, a candidate for the bifidus factor in human milk	Nishimoto, M.; Kitaoka, M.	*Biosci., Biotechnol., Biochem. 71 (8),* 2101-2104	2007 Aug
Hydrophilic interaction liquid chromatography—charged aerosol detection as a straightforward solution for simultaneous analysis of ascorbic acid and dehydroascorbic acid	Nováková, L.; Solichová, D.; Solich, P.	*J. Chromatogr., A. 1216 (21),* 4574–4581	2009 May 22

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No effect on adenoma formation in Min mice after moderate amount of flaxseed	Oikarinen, S.; Heinonen, S. M.; Nurmi, T.; Adlercreutz, H.; Mutanen, M.	*Eur. J. Nutr. 44 (5),* 273–280	2005 Aug
Measurement of isoflavones using liquid chromatography with multi-channel coulometric electrochemical detection	Ouchi, K.; Gamache, P.; Acworth, I.; Watanabe, S.	*BioFactors. 22 (1–4),* 353–356	2004
Quantitation of clovamide-type phenylpropenoic acid amides in cells and plasma using high-performance liquid chromatography with a coulometric electrochemical detector	Park, J. B.	*J. Agric. Food Chem. 53 (21),* 8135–8140	2005 Oct 19
Synthesis, HPLC measurement and bioavailability of the phenolic amide amkamide	Park, J. B.	*J. Chromatogr. Sci.* [Epub ahead of print]	2013 May 27
Synthesis of safflomide and its HPLC measurement in mouse plasma after oral administration	Park, J. B.; Chen, P.	*J. Chromatogr., B: Anal. Technol. Biomed. Life Sci.* 852 (1–2), 398–402	2007 Jun 1
Determination of lignans in human plasma by liquid chromatography with coulometric electrode array detection	Peñalvo, J. L.; Nurmi, T.; Haajanen, K.; Al-Maharik, N.; Botting, N.; Adlercreutz, H.	*Anal. Biochem. 332 (2),* 384–393	2004 Sep 15
Supercritical antisolvent fractionation of lignans from the ethanol extract of flaxseed	Perretti, G.; Virgili, C.; Troilo, A.; Marconi, O.; Regnicoli, G. F.; Fantozzi, P.	*J. Supercrit. Fluids 75,* 94–100	2013 Mar
Analysis of flavonoids in honey by HPLC coupled with coulometric electrode array detection and electrospray ionization mass spectrometry	Petrus, K.; Schwartz, H.; Sontag, G.	*Anal. Bioanal. Chem. 400 (8),* 2555–2563	2011 Jun
High-dose supplementation with natural α-tocopherol does neither alter the pharmacodynamics of atorvastatin nor its phase I metabolism in guinea pigs	Podszun, M. C.; Grebenstein, N.; Hofmann, U.; Frank, J.	*Toxicol. Appl. Pharmacol. 266 (3),* 452–458	2013 Feb 1
Application of high-performance liquid chromatography with charged aerosol detection for universal quantitation of undeclared phosphodiesterase-5 inhibitors in herbal dietary supplements	Poplawska, M.; Blazewicz, A.; Bukowinska, K.; Fijalek, Z.	*J. Pharm. Biomed. Anal. 84,* 232–243	2013 Oct
Isolation and analysis of ginseng: advances and challenges	Qi, L.; Wang, C.; Yuan, C.	*Nat. Prod. Rep. 28 (3),* 467–495	2011 Mar
Folate analysis in complex food matrices: Use of a recombinant Arabidopsis γ-glutamyl hydrolase for folate deglutamylation	Ramos-Parra, P. A.; Urrea-López, R.; Díaz de la Garza, R. I.	*Food Res. Int. 54 (1),* 177–185	2013 Nov
Optimisation of gradient HPLC analysis of phenolic compounds and flavonoids in beer using a coularray detector	Rehová, L.; Skeríková, V.; Jandera, P.	*J. Sep. Sci. 27 (15–16),* 1345–1359	2004 Nov
Chiral separation of (+)/(-)-catechin from sulfated and glucuronidated metabolites in human plasma after cocoa consumption	Ritter, C.; Zimmermann, B. F.; Galensa, R.	*Anal. Bioanal. Chem. 397 (2),* 723–730	2010 May

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Analysis of alkylresorcinols in cereal grains and products using ultrahigh-pressure liquid chromatography with fluorescence, ultraviolet, and CoulArray electrochemical detection	Ross, A. B.	*J. Agric. Food Chem. 60 (36),* 8954–8962	2012 Sep 12
Rapid and sensitive analysis of alkylresorcinols from cereal grains and products using HPLC-CoulArray-based electrochemical detection	Ross, A. B.; Kochhar, S.	*J. Agric. Food Chem. 57 (12),* 5187–5193	2009 Jun 24
Analysis of soy isoflavone plasma levels using HPLC with coulometric detection in postmenopausal women	Saracino, M. A.; Raggi, M. A.	*J. Pharm. Biomed. Anal. 53 (3),* 682–687	2010 Nov 2
A biosynthetic pathway for BE-7585A, a 2-thiosugar-containing angucycline-type natural product	Sasaki, E.; Ogasawara, Y.; Liu, H. W.	*J. Am. Chem. Soc. 132 (21),* 7405–7417	2010 Jun 2
The senescence-accelerated mouse-prone 8 is not a suitable model for the investigation of cardiac inflammation and oxidative stress and their modulation by dietary phytochemicals	Schiborr, C.; Schwamm, D.; Kocher, A.; Rimbach, G.; Eckert, G. P.; Frank, J.	*Pharmacol. Res. 74,* 113–120	2013 Aug
Comprehensive impurity profiling of nutritional infusion solutions by multidimensional off-line reversed-phase liquid chromatography × hydrophilic interaction chromatography-ion trap mass-spectrometry and charged aerosol detection with universal calibration	Schiesel, S.; Lämmerhofer, M.; Lindner, W.	*J. Chromatogr., A. 1259,* 100–10	2012 Oct 12
The effect of α-tocopherol supplementation on training-induced elevation of S100B protein in sera of basketball players	Schulpis, K. H.; Moukas, M.; Parthimos, T.; Tsakiris, T.; Parthimos, N.; Tsakiris, S.	*Clin. Biochem. 40 (12),* 900–906	2007 Aug
Determination of secoisolariciresinol, lariciresinol and isolariciresinol in plant foods by high performance liquid chromatography coupled with coulometric electrode array detection	Schwartz, H.; Sontag, G.	*J. Chromatogr., B: Anal. Technol. Biomed. Life Sci.* 838 (2), 78–85	2006 Jul 11
Assessment of probiotic strains ability to reduce the bioaccessibility of aflatoxin M 1 in artificially contaminated milk using an in vitro digestive model	Serrano-Niño, J. C.; Cavazos-Garduño, A.; Hernandez-Mendoza, A.; Applegate, B.; Ferruzzi, M. G.; San Martin-González, M. F.; García, H. S.	*Food Control 31 (1),* 202–207	2013 May
Intestinal uptake of quercetin-3-glucoside in rats involves hydrolysis by lactase phlorizin hydrolase	Sesink, A. L.; Arts, I. C.; Faassen-Peters, M.; Hollman, P. C.	*J. Nutr. 133 (3),* 773–776	2003 Mar
Quercetin glucuronides but not glucosides are present in human plasma after consumption of quercetin-3-glucoside or quercetin-4'-glucoside	Sesink, A. L.; O'Leary, K. A.; Hollman, P. C.	*J. Nutr. 131 (7),* 1938–1941	2001 Jul
Co-administration of quercetin and catechin in rats alters their absorption but not their metabolism	Silberberg, M.; Morand, C.; Manach, C.; Scalbert, A.; Remesy, C.	*Life Sci. 77 (25),* 3156–3167	2005 Nov 4
Nutritional status is altered in the self-neglecting elderly	Smith, S. M.; Mathews Oliver, S. A.; Zwart, S. R.; Kala, G.; Kelly, P. A.; Goodwin, J. S.; Dyer, C. B.	*J. Nutr. 136 (10),* 2534–2541	2006 Oct

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Binding of heterocyclic aromatic amines by lactic acid bacteria: results of a comprehensive screening trial	Stidl, R.; Sontag, G.; Koller, V.; Knasmüller, S.	*Mol. Nutr. Food Res. 52 (3),* 322–329	2008 Mar
Direct separation and detection of biogenic amines by ion-pair liquid chromatography with chemiluminescent nitrogen detector	Sun, J.; Guo, H. X.; Semin, D.; Cheetham, J.	*J. Chromatogr., A. 1218 (29),* 4689–4697	2011 Jul 22
Rapid purification method for fumonisin B1 using centrifugal partition chromatography	Szekeres, A.; Lorántfy, L.; Bencsik, O.; Kecskeméti, A.; Szécsi, Á.; Mesterházy, Á.; Vágvölgyi, C.	*Food Addit. Contam. 30 (1),* 147–155	2013
Determination of coenzyme Q10 in over-the-counter dietary supplements by high-performance liquid chromatography with coulometric detection	Tang, P. H.	*J. AOAC Int. 89 (1),* 35–39	2006 Jan–Feb
α-Tocopherol supplementation restores the reduction of erythrocyte glucose-6-phosphate dehydrogenase activity induced by forced training	Tsakiris, S.; Reclos, G. J.; Parthimos, T.; Tsakiris, T.; Parthimos, N.; Schulpis, K. H.	*Pharmacol. Res. 54 (5),* 373–379	2006 Nov
Tissue distribution of isoflavones in ewes after consumption of red clover silage	Urpi-Sarda, M.; Morand, C.; Besson, C.; Kraft, G.; Viala, D.; Scalbert, A.; Besle, J. M.; Manach, C.	*Arch. Biochem. Biophys. 476 (2),* 205–210	2008 Aug 15
Performance evaluation of charged aerosol and evaporative light scattering detection for the determination of ginsenosides by LC	Wang, L.; He, W. S.; Yan, H. X.; Jiang, Y.; Bi, K. S.; Tu, P. F.	*Chromatographia 70 (3–4),* 603–608	2009 Aug
Catechins are bioavailable in men and women drinking black tea throughout the day	Warden, B. A.; Smith, L. S.; Beecher, G. R.; Balentine, D. A.; Clevidence, B. A.	*J. Nutr. 131 (6),* 1731–1737	2001 Jun
Identification and quantification of polyphenol phytoestrogens in foods and human biological fluids	Wilkinson, A. P.; Wähälä, K.; Williamson, G.	*J. Chromatogr., B: Anal. Technol. Biomed. Life Sci. 777 (1–2),* 93–109	2002 Sep 25
Bioavailability and pharmacokinetics of caffeoylquinic acids and flavonoids after oral administration of Artichoke leaf extracts in humans	Wittemer, S. M.; Ploch, M.; Windeck, T.; Müller, S. C.; Drewelow, B.; Derendorf, H.; Veit, M.	*Phytomedicine 12 (1–2),* 28–38	2005 Jan
Validated method for the determination of six metabolites derived from artichoke leaf extract in human plasma by high-performance liquid chromatography-coulometric-array detection	Wittemer, S. M.; Veit, M.	*J. Chromatogr., B: Anal. Technol. Biomed. Life Sci. 793 (2),* 367–375	2003 Aug 15
HPLC in natural product analysis: The detection issue	Wolfender, J. L.	*Planta Med. 75 (07),* 719–734	2009 Jun
Simultaneous determination of isoflavones and bisphenol A in rat serum by high-performance liquid chromatography coupled with coulometric array detection	Yasuda, S.; Wu, P. S.; Hattori, E.; Tachibana, H.; Yamada, K.	*Biosci., Biotechnol., Biochem. 68 (1),* 51–58	2004 Jan
Impurities from polypropylene microcentrifuge tubes as a potential source of interference in simultaneous analysis of multiple lipid-soluble antioxidants by HPLC with electrochemical detection	Yen, H. C.; Hsu, Y. T.	*Clin. Chem. Lab. Med. 42 (4),* 390–395	2004 Apr

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Simultaneous determination of triterpenoid saponins from *pulsatilla koreana* using high performance liquid chromatography coupled with a charged aerosol detector (HPLC-CAD)	Yeom, H.; Suh, J. H.; Youm, J. R.; Han, S. B.	*Bull. Korean Chem. Soc. 31 (5),* 1159–1164	2010
DPPH radical scavenging activities of 31 flavonoids and phenolic acids and 10 extracts of Chinese materia medica	Yuan, Y.; Chen, C.; Yang, B.; Kusu, F.; Kotani, A.	*Zhongguo Zhongyao Zazhi 34 (13),* 1695–1700	2009 Jul
Determination of residual clenbuterol in pork meat and liver by HPLC with electrochemical detection	Zhang, X. Z.; Gan, Y. R.; Zhao, F. N.	*Yaoxue Xuebao 39 (4),* 276–280	2004 Apr
Identification of equol producers in a Japanese population by high-performance liquid chromatography with coulometric array for determining serum isoflavones	Zhao, J. H.; Sun, S. J.; Arao, Y.; Oguma, E.; Yamada, K.; Horiguchi, H.; Kayama, F.	*Phytomedicine 13 (5),* 304–309	2006 May
Simultaneous sampling of volatile and non-volatile analytes in beer for fast fingerprinting by extractive electrospray ionization mass spectrometry	Zhu, L.; Hu, Z.; Gamez, G.; Law, W. S.; Chen, H.; Yang, S.; Chingin, K.; Balabin, R. M.; Wang, R.; Zhang, T.; Zenobi, R.	*Anal. Bioanal. Chem. 398 (1),* 405–413	2010 Sep
Comparison of various easy-to-use procedures for extraction of phenols from apricot fruits	Zitka, O.; Sochor, J.; Rop, O.; Skalickova, S.; Sobrova, P.; Zehnalek, J.; Beklova, M.; Krska, B.; Adam, V.; Kizek, R.	*Molecules 16 (4),* 2914–2936	2011 Apr 4

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Development of analytical procedures to study changes in the composition of meat phospholipids caused by induced oxidation	Cascone, A.; Eerola, S.; Ritieni, A.; Rizzo, A.	*J. Chromatogr., A 1120 (1–2),* 211–220	2006 Jul 7
Evaporative light scattering and charged aerosol detector.	Chaminade, P.	Chapter 5. In *Hyphenated and Alternative Methods of Detection in Chromatography,* Chromatographic Science Series; Shalliker, A., Ed.; Taylor & Francis Group, LLC: Boca Raton, FL.; 145–160	2012
Simple and efficient profiling of phospholipids in phospholipase D-modified soy lecithin by HPLC with charged aerosol detection	Damnjanovic´, J.; Nakano, H.; Iwasaki, Y.	*J. Am. Oil Chem. Soc. 90 (7),* 951–957	2013 Jul
Discriminating olive and non-olive oils using HPLC-CAD and chemometrics	de la Mata-Espinosa, P.; Bosque-Sendra, J. M.; Bro, R.; Cuadros-Rodríguez, L.	*Anal. Bioanal. Chem. 399 (6),* 2083–2092	2011 Feb
Olive oil quantification of edible vegetable oil blends using triacylglycerols chromatographic fingerprints and chemometric tools	de la Mata-Espinosa, P.; Bosque-Sendra, J. M.; Bro, R.; Cuadros-Rodríguez, L.	*Talanta 85 (1),* 177–182	2011 Jul 15
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Quantification of pegylated phospholipids decorating polymeric microcapsules of perfluorooctyl bromide by reverse phase HPLC with a charged aerosol detector	Díaz-López, R.; Libong, D.; Tsapis, N.; Fattal, E.; Chaminade, P.	*J. Pharm. Biomed. Anal. 48 (3),* 702–707	2008 Nov 4
Squalene emulsions for parenteral vaccine and drug delivery	Fox, C. B.	*Molecules 14 (9),* 3286–3312	2009 Sep 1
Interactions between parenteral lipid emulsions and container surfaces	Gonyon, T.; Tomaso, A.; Kotha, P.; Owen, H.; Patel, D.; Carter, P.; Cronin, J.; Green, J.	*PDA J. Pharm. Sci. and Tech. 67 (3),* 247–254	2013 May–Jun
Composition analysis of positional isomers of phosphatidylinositol by high-performance liquid chromatography	Iwasaki, Y.; Masayama, A.; Mori, A.; Ikeda, C.; Nakano, H.	*J. Chromatogr., A 1216 (32),* 6077–6080	2009 Aug 7
Determination of phospholipid and its degradation products in liposomes for injection by HPLC-charged aerosol detection (CAD)	Jiang, Q.; Yang, R.; Mei, X.	*Chinese Pharmaceutical Journal (Zhongguo Yaoxue Zazhi, Beijing, China) 42 (23),* 1794–1796	2007

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Lipids

Title	Authors	Publication	Publication Date
Rapid quantification of yeast lipid using microwave-assisted total lipid extraction and HPLC-CAD	Khoomrung, S.; Chumnanpuen, P.; Jansa-Ard, S.; Ståhlman, M.; Nookaew, I.; Borén, J.; Nielsen, J.	*Anal. Chem. 85 (10),* 4912–4919	2013 May 21
A new liquid chromatography method with charge aerosol detector (CAD) for the determination of phospholipid classes. Application to milk phospholipids	Kieibowicz, G.; Micek, P.; Wawrzenczyk, C.	*Talanta 105,* 28–33	2013 Feb 15
An LC method for the analysis of phosphatidylcholine hydrolysis products and its application to the monitoring of the acyl migration process	Kiełbowicz, G.; Smuga, D.; Gładkowski, W.; Chojnacka, A.; Wawrzeńczyk, C.	*Talanta 94,* 22–29	2012 May 30
Separation of acylglycerols, FAME and FFA in biodiesel by size exclusion chromatography	Kittirattanapiboon, K.; Krisnangkurá, K.	*Eur. J. Lipid Sci. Technol. 110 (5),* 422–427	2008 Mar 17
Quantitation of triacylglycerols from plant oils using charged aerosol detection with gradient compensation	Lísa, M.; Lynen, F.; Holčapek, M.; Sandra, P.	*J. Chromatogr., A. 1176 (1–2),* 135–142	2007 Dec 28
Quantitative study of the stratum corneum lipid classes by normal phase liquid chromatography: comparison between two universal detectors	Merle, C.; Laugel, C.; Chaminade, P.; Baillet-Guffroy, A.	*J. Liq. Chromatogr. Relat. Technol. 33,* 629–644	2010 Mar
The analysis of lipids via HPLC with a charged aerosol detector	Moreau, R. A.	*Lipids 41 (7),* 727–34	2006 Jul
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Simultaneous assessment of lipid classes and bile acids in human intestinal fluid by solid-phase extraction and HPLC methods	Persson, E.; Löfgren, L.; Hansson, G.; Abrahamsson, B.; Lennernäs, H.; Nilsson, R.	*J. Lipid Res. 48 (1),* 242–251	2007 Jan

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Title	Authors	Publication	Publication Date
The use of charged aerosol detection with HPLC for the measurement of lipids	Plante, M.; Bailey, B.; Acworth, I.	*Methods Mol. Biol.* (Totowa, NJ, U.S.) 579, 469–482	2009
Comparison between charged aerosol detection and light scattering detection for the analysis of Leishmania membrane phospholipids	Ramos, R. G.; Libong, D.; Rakotomanga, M.; Gaudin, K.; Loiseau, P. M.; Chaminade, P.	*J. Chromatogr., A. 1209 (1–2),* 88–94	2008 Oct 31
Authentication of geographical origin of palm oil by chromatographic fingerprinting of triacylglycerols and partial least square-discriminant analysis	Ruiz-Samblás, C.; Arrebola-Pascual, C.; Tres, A.; van Ruth, S.; Cuadros-Rodríguez, L.	*Talanta. 116,* 788–793	2013 Nov 15
Simple and precise detection of lipid compounds present within liposomal formulations using a charged aerosol detector	Schönherr, C.; Touchene, S.; Wilser, G.; Peschka-Süss, R.; Francese, G.	*J. Chromatogr., A. 1216 (5),* 781–786	2009 Jan 30
Determination of intralumenal individual bile acids by HPLC with charged aerosol detection	Vertzoni, M.; Archontaki, H.; Reppas, C.	*J. Lipid Res. 49 (12),* 2690–2695	2008 Dec
Neurolipids and the use of a charged aerosol detector	Waraska, J.; Acworth, I.	*Am. Biotechnol. Lab. 26 (1),* 12–13	2008

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Product Number	Technique	Title
AB 119	UV	Rapid Separation of Paclitaxel and Related Compounds in Paclitaxel Injection
AB 134	MS	LC-MS Analysis of Anthocyanins in Bilberry Extract
AB 139	UV	Separation of Schizandrin, Schizandrin A, and Schizandrin B in a Tablet Sample
AB 153	UV	Save the Flavor – Robust Iso-α-Acids Assaying in Beer within Ten Minutes
AB 155	UV	Monitor the Brewing Process with LC-Transformation of Hop alpha-Acids into Beer Iso-alpha-Acids
AN 109	FLD	Determination of Glyphosate by Cation-Exchange Chromatography with Postcolumn Derivatization
AN 156	UV	The Everlasting Paradigm-Keep Beer Tradition or Prevent Beer from a Skunky Off-Flavor?
AN 196	FLD	Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Edible Oils by Donor-Acceptor Complex Chromatography (DACC)-HPLC with Fluorescent Detection
AN 207	UV	Chromatographic Fingerprinting of *Flos Chrysanthema indici* Using HPLC
AN 213	UV/FLD	Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Tap Water Using on-Line Solid-Phase Extraction Followed by HPLC with UV and Fluorescence Detections
AN 216	UV	Determination of Water- and Fat-Soluble Vitamins in Functional Waters by HPLC with UV-PDA Detection
AN 224	UV	Determination of Melamine in Milk Powder by Reversed-Phase HPLC with UV Detection
AN 232	UV	Determination of Anthraquinones and Stilbenes in Giant Knotweed Rhizome by HPLC with UV Detection
AN 236	UV	Determination of Iodide and Iodate in Seawater and Iodized Table Salt by HPLC-UV Detection
AN 245	UV	Fast Analysis of Dyes in Foods and Beverages
AN 251	UV	Determination of Water- and Fat-Soluble Vitamins in Nutritional Supplements by HPLC with UV Detection
AN 252	UV	HPLC Assay of Water-Soluble Vitamins, Fat-Soluble Vitamins, and a Preservative in Dry Syrup Multivitamin Formulation
AN 261	UV	Sensitive Determination of Microcystins in Drinking and Environmental Waters
AN 264	UV	Fast Determination of Anthocyanins in Pomegranate Juice
AN 266	FLD	Determination of Sialic Acids Using UHPLC with Fluorescence Detection
AN 272	FLD	Faster Yet Sensitive Determination of N-Methylcarbamates in Rice, Potato, and Corn by HPLC
AN 275	UV	Sensitive Determination of Catechins in Tea by HPLC
AN 287	UV	Two-Dimensional HPLC Combined with On-Line SPE for Determination of Sudan Dyes I–IV in Chili Oil
AN 292	UV	Determination of Aniline and Nitroanilines in Environmental and Drinking Waters by On-Line SPE
AN 293	CAD and UV	Steviol Glycoside Determination by HPLC with Charged Aerosol and UV Detections Using the Acclaim Trinity P1 Column
AN 299	UV	HPLC Analysis of Six Active Components of *Caulis Ionicerae* Using a Phenyl-1 Column
AN 1008	UV	Determination of Nitidine Chloride, Toddalolactone, and Chelerythrine Chloride by HPLC

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Product Number	Technique	Title
AN 1020	EC, UV	Chalcinoids and Bitter Acids in Beer by HPLC with UV and ECD
AN 1023	UV	Determination of Sudan Dyes I–IV in Curry Paste
AN 1026	CAD	Fatty Acid Esters at Low Nanogram Levels
AN 1027	CAD	Ginseng
AN 1028	CAD	Ginkgo biloba
AN 1029	CAD	Black Cohosh
AN 1030	CAD	Soy Saponins
AN 1032	CAD	Unsaturated Fatty Acid: Arachidonic, Linoleic, Linolenic and Oleic Acids
AN 1033	CAD	Corn Syrup
AN 1034	CAD	Honey Sugars
AN 1035	CAD	Phenolic Acids
AN 1036	CAD	Water-Soluble Antioxidants: Ascorbic Acid, Glutathione and Uric Acid
AN 1037	CAD	Artificial Sweeteners-Global Method
AN 1039	CAD	Simultaneous Measurement of Glycerides (Mono-, Di- and Triglycerides) and Free Fatty Acids in Palm Oil
AN 1040	CAD	Analysis of Commercially Available Products Containing Stevia
AN 1041	CAD	Phytosterols
AN 1042	UV	Rapid Separation of Anthocyanins in Cranberry and Bilberry Extracts Using a Core-Shell Particle Column
AN 1045	UV	Determination of Phthalates in Drinking Water by UHPLC with UV Detection
AN 1046	UV	Determination of Phenylurea Compounds in Tap Water and Bottled Green Tea
AN 1055	CAD	Determination of Virginiamycin, Erythromycin, and Penicillin in Dried Distillers Grains with Solubles
AN 1063	ECD	Targeted Analyses of Secondary Metabolites in Herbs, Spices, and Beverages Using a Novel Spectro-Electro Array Platform
AN 1064	ECD	Product Authentication and Adulteration Determination Using a Novel Spectro-Electro Array Platform
AN 1067	UV	Determination of Carbendazim in Orange Juice
AN 1069	UV	Two-Dimensional HPLC Determination of Water-Soluble Vitamins in a Nutritional Drink
AN 1070	UV	Determination of Inositol Phosphates in Dried Distillers Grains and Solubles
AN 20583	UV	Determination of Catechins and Phenolic Acids in Red Wine by Solid Phase Extraction and HPLC
AN 20610	UV	Fast Analysis of Coffee Bean Extracts Using a Solid Core HPLC Column
AN 20663	CAD	Comparative Analysis of Cooking Oils Using a Solid Core HPLC Column
AN 20847	CAD	Analysis of a Sports Beverage for Electrolytes and Sugars Using Multi-Mode Chromatography with Charged Aerosol Detection

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Product Number	Technique	Title
AN 70158	CAD	Novel Universal Approach for the Measurement of Natural Products in a Variety of Botanicals and Supplements
AN 70277	CAD	Simultaneous Analysis of Glycerides and Fatty Acids in Palm Oil
AU 144	UV	Determination of Hexavalent Chromium in Drinking Water Using Ion Chromatography
AU 170	UV	Fast Determination of Vanillin and its Synthesis Precursor by HPLC
AU 182	CAD	Measuring Lactose in Milk: A Validated Method
AU 184	CAD, UV	Mogroside V Determination by HPLC with Charged Aerosol and UV Detections
CAN 106	UV	Determination of the Punicalagins Found in Pomegranate by High Performance Liquid Chromatography
CAN 111	CAD	Determination of Triterpenes in *Centella asiatica* (Gotu Kola) by HPLC-CAD
CAN 112	CAD	Determination of Ginsenosides in Panax ginseng by HPLC-CAD
CAN 115	FLD	Clean-Up and Analysis of Aflatoxins and Ochratoxin A in Herbs and Spices
LPN 2062	MS	Profiling Analysis of 15 Prominent Naturally Occurring Phenolic Acids by LC-MS
LPN 2069	FLD	Fast and Effective Determination of Aflatoxins in Grains or Food Using Accelerated Solvent Extraction followed by HPLC
LPN 2421	UV	Achieving Maximum Productivity by Combining UHPLC with Advanced Chromatographic Techniques
LPN 2818	CAD	Analysis of Fat-Soluble Vitamins and Antioxidants in Supplements by RP-HPLC
LPN 2870	FLD	Benefits of High-Speed Wavelength Switching in UHPLC Methods Using Fluorescence Detection
LPN 2930	CAD	Determination of the Composition of Natural Products by HPLC with Charged Aerosol Detection
LPN 2923	CAD	Simple and Direct Analysis of Falcarinol and Other Polyacetylenic Oxylipins in Carrots by Reversed-Phase HPLC and Charged Aerosol Detection
LPN 2931	CAD	Quantification of Underivatized Omega-3 and Omega-6 Fatty Acids in Foods by HPLC CAD
LPN 2932	ECD	A Versatile Detector for the Sensitive and Selective Measurement of Numerous Fat-Soluble Vitamins and Antioxidants in Human Plasma and Plant Extracts
LPN 2934	CAD	Sensitive Analysis of Commonly Used Artificial and Natural Sweeteners Including Stevia and Their Impurities and Degradation Products
LPN 2991	CAD	Evaluation of Methods for the Characterization and Quantification of Polysorbates and Impurities Along with Other Surfactants and Emulsifiers Used in the Food and Pharmaceutical Industries
PN 70026	CAD	Carbohydrate Analysis Using PAD, FLD, CAD and MS Detectors
PN 70037	CAD	Sensitive HPLC Method for Triterpenoid Analysis Using Charged Aerosol Detection with Improved Resolution
PN 70055	CAD	Direct Analysis of Surfactants using HPLC with Charged Aerosol Detection
PN 70138	UV	Rapid Determination of Polyphenol Antioxidants in Green Tea and Cranberry Extract Using Core Shell Columns
PN 70538	CAD	Analysis of Silicone Oils by HPLC-CAD
PN 70540	CAD, ECD	Profiling *Hoodia* Extracts by HPLC with CAD, ECD, Principal Component Analysis

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References

Ion Chromatography References

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Product Number	Technique	Title
AB 127	IC-PAD	Determination of Carbohydrates in Fruit Juice Using Capillary High-Performance Anion-Exchange Chromatography
AB 135	IC-SC	Determination of Anions and Organic Acids in Brewed Coffee Samples Using Capillary IC
AB 137	IC-SC	Determination of Inorganic and Organic Acids in Apple and Orange Juice Samples Using Capillary IC
AN 25	IC-SC	Determination of Inorganic Ions and Organic Acids in Non-Alcoholic Carbonated Beverages
AN 37	IC-PAD	Determination of Iodide and Iodate in Soy- and Mil-Based Infant Formulas
AN 46	IC-PAD	Ion Chromatography: A Versatile Technique for the Analysis of Beer
AN 54	IC-PAD	Determination of Total and Free Sulfite in Foods and Beverages
AN 67	IC-PAD	Determination of Plant-Derived Neutral Oligo- and Polysaccharides
AN 81	IC-SC	Ion Chromatographic Determination of Oxyhalides and Bromide at Trace Level Concentrations in Drinking Water Using direct Injection
AN 82	IC-PAD	Analysis of Fruit Juice Adulterated with Medium Invert Sugar from Beets
AN 87	IC-PAD	Determination of Sugar Alcohols in Confections and Fruit Juices by High-Performance Anion-Exchange Chromatography with Pulsed Amperometric Detection
AN 101	IC-SC	Trace Level Determination of Bromate in Ozonated Drinking Water Using Ion Chromatography
AN 112	IC-UV	Determination of Nitrate and Nitrite in Meat Using High-Performance Anion-Exchange Chromatography
AN 121	IC-SC	Analysis of Low Concentrations of Perchlorate in Drinking Water and Ground Water by Ion Chromatography
AN 123	IC-SC	Determination of Inorganic Anions and Organic Acids in Fermentation Broths
AN 133	IC-SC	Determination of Inorganic Anions in Drinking Water by Ion Chromatography
AN 136	IC-SC and IC-UV	Determination of Inorganic Oxyhalide Disinfection Byproduct Anions and Bromide in Drinking Water Using Ion Chromatography with the Addition of a Postcolumn Reagent for Trace Bromate Analysis
AN 140	IC-SC	Fast Analysis of Anions in Drinking Water by Ion Chromatography
AN 143	IC-SC	Determination of Organic Acids in Fruit Juices
AN 149	IC-SC	Determination of Chlorite, Bromate, Bromide, and Chlorate in Drinking Water by Ion Chromatography with an On-Line-Generated Postcolumn Reagent for Sub-µg/L Bromate Analysis
AN 150	IC-PAD	Determination of Amino Acids in Cell Cultures and Fermentation Broths
AN 154	IC-SC	Determination of Inorganic Anions in Environmental Waters Using a Hydroxide-Selective Column
AN 155	IC-PAD	Determination of Trans-Galactooligosaccharides in Foods by AOAC Method 2001.02

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Product Number	Technique	Title
AN 165	IC-SC	Determination of Benzoate in Liquid Food Products by Reagent-Free Ion Chromatography
AN 167	IC-SC	Determination of Trace Concentrations of Oxyhalides and Bromide in Municipal and Bottled Waters Using a Hydroxide-Selective Column with a Reagent-Free Ion Chromatography System
AN 168	IC-UV	Determination of Trace Concentrations of Disinfection By-Product Anions and Bromide in Drinking Water Using Reagent-Free Ion Chromatography Followed by Postcolumn Addition of Iol-Dianisidine for Trace Bromate Analysis
AN 169	IC-SC	Rapid Determination of Phosphate and Citrate in Carbonated Soft Drinks Using a Reagent-Free Ion Chromatography System
AN 172	IC-SC	Determination of Azide in Aqueous Samples by Ion Chromatography with Suppressed Conductivity Detection
AN 173	IC-PAD	Direct Determination of Cyanide in Drinking Water by Ion Chromatography with Pulsed Amperometric Detection (PAD)
AN 178	IC-SC	Improved Determination of Trace Concentrations of Perchlorate in Drinking Water Using Preconcentration with Two-Dimensional Ion Chromatography and Suppressed Conductivity Detection
AN 182	IC-SC and IC-PAD	Determination of Biogenic Amines in Alcoholic Beverages by Ion Chromatography with Suppressed Conductivity and Integrated Pulsed Amperometric Detections
AN 183	IC-SC and IC-PAD	Determination of Biogenic Amines in Fermented and Non-Fermented Foods Using Ion Chromatography with Suppressed Conductivity and Integrated Pulsed Amperometric Detections
AN 187	IC-SC	Determination of sub-µg/L Bromate in Municipal Waters Using Preconcentration with Two-Dimensional Ion Chromatography and Suppressed Conductivity Detection
AN1 88	IC-PAD	Determination of Glycols and Alcohols in Fermentation Broths Using Ion-Exclusion Chromatography and Pulsed Amperometric Detection
AN 197	IC-PAD	Determination of Glucosamine in Dietary Supplements Using HPAE-PAD
AN 227	ICE-PAD	Determination of Total Cyanide in Municipal Wastewater and Drinking Water Using Ion-Exclusion Chromatography with Pulsed Amperometric Detection (ICE-PAD)
AN 248	IC-PAD	Determination of Lactose in Lactose-Free Milk Products by High-Performance Anion-Exchange Chromatography with Pulsed Amperometric Detection
AN 253	IC-PAD	HPAE-PAD Determination of Infant Formula Sialic Acids
AN 270	IC-PAD	Determination of Hydroxymethylfurfural in Honey and Biomass
AN 273	IC-SC	Determination of Organic Acids in Fruit Juices and Wines by High-Pressure IC
AN 279	IC-SC	Time Savings and Improved Reproducibility of Nitrate and Nitrite Ion Chromatography Determination in Milk Samples
AN 280	IC-PAD	Carbohydrates in Coffee: AOAC Method 995.13 vs a New Fast Ion Chromatography Method
AN 295	IC-SC	Determination of Phytic Acid in Soybeans and Black Sesame Seeds
AN 1007	IC-SC	Determination of Mono-, Di-, and Triphosphates and Citrate in Shrimp by Ion Chromatography

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Product Number	Technique	Title
AN 1044	IC-SC	Determination of Anions in Dried Distillers Grains with Solubles
AN 1068	IC-SC	Determination of Organic Acids in Fruit Juices and Wines by High-Pressure IC
AU 132	IC-UV	Determination of Nitrite and Nitrate in drinking Water by Ion Chromatography with Direct UV Detection
AU 144	IC-UV	Determination of Hexavalent Chromium in Drinking Water Using Ion Chromatography
AU 148	IC-SC	Determination of Perchlorate in Drinking Water Using Reagent-Free Ion Chromatography
AU 150	IC-PAD	Determination of Plant-Derived Neutral Oligo- and Polysaccharides Using the CarboPac PA200
AU 151	IC-PAD	Determination of Sucralose in Reduced- Carbohydrate Colas using High-Performance Anion-Exchange Chromatography with Pulsed Amperometric Detection
AU 189	IC-SC	Determination of Choline in Infant Formula and Other Food Samples by IC
LPN 2982	IC-SC	Determination of Inorganic Anions and Organic Acids in Beverages Using a Capillary IC on a Monolith Anion-Exchange Column
PN 70743	IC-SC	Determination of Perchlorate Levels in Food and Soil Samples Using Accelerated Solvent Extraction and Ion Chromatography
TN 20	IC-PAD	Analysis of Carbohydrates by High-Performance Anion-Exchange Chromatography with Pulsed Amperometric Detection (HPAE-PAD)
TN 126	IC-SC	Determination of Organic Acids in Beer Samples Using a High-Pressure Ion Chromatography System
TN 135	IC-PAD	Determinations of Monosaccharides and Disaccharides in Beverages by Capillary HPAE-PAD

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Sample Preparation References

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Multiresidue method for the analysis of pesticide residues in fruits and vegetables by accelerated solvent extraction and capillary gas chromatography	Adou, K.; Bontoyan, W. R.; Sweeney, P. J.	*J. Agric. Food Chem. 49 (9),* 4153–4160	2001 Sep
The development of an optimized sample preparation for trace level detection of 17α-ethinylestradiol and estrone in whole fish tissue	Al-Ansari, A. M.; Saleem, A.; Kimpe, L. E.; Trudeau, V. L.; Blais, J. M.	*J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 879 (30),* 3649–52	2011 Nov
Determination of polyphenolic profiles of basque cider apple varieties using accelerated solvent extraction	Alonso-Salces, R. M.; Korta, E.; Barranco, A.; Berrueta, L.A.; Gallo, B.; Vicent, F.	*J. Agric. Food Chem. 49 (8),* 3761–376	2001
Pressurized liquid extraction for the determination of polyphenols in apple	Alonso-Salces, R. M.; Korta, E.; Barranco, A.; Berrueta, L. A.; Gallo, B.; Vicente, F.;	*J. Chromatogr., A. 933 (1–2),* 37–43	2001 Nov
Methods for extraction and determination of phenolic acids in medicinal plants: a review	Arceusz, A.; Wesolowski, M.; Konieczynski, P.	*Nat. Prod. Commun. 8 (12),* 1821–9	2013 Dec
Study of an accelerated solvent extraction procedure for the determination of acaricide residues in honey by high-performance liquid chromatography-diode array detector	Bakkali, A.; Korta, E.; Berrueta, L. A.	*J. Food Protection 65 (1),* 161–166	2002
Pressurized liquid extraction of medicinal plants	Benthin, B.; Danz, H.; Hamburger, M.	*J. Chromatogr., A. 837 (1-2),* 211–9	1999 Apr
Comparison of the chemical composition of extracts from *Scutellaria lateriflora* using accelerated solvent extraction and supercritical fluid extraction versus standard hot water or 70% ethanol extraction	Bergeron, C.; Gafner, S.; Clausen, E.; Carrier, D. J.	*J. Agric. Food Chem. 53 (8),* 3076–80	2005 Apr
Polybrominated diphenyl ethers (PBDEs) in Mediterranean mussels (*Mytilus galloprovincialis*) from selected Apulia coastal sites evaluated by GC-HRMS	Bianco, G.; Novario, G.; Anzilotta, G.; Palma, A.; Mangone, A.; Cataldi, T. R.	*J. Mass Spectrom. 45 (9),* 1046–55	2010 Sep
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Pressurized liquid extraction of lipids for the determination of oxysterols in egg-containing food	Boselli, E.; Velazco, V.; Caboni, M. F.; Lercker, G.	*J. Chromatogr., A. 11; 917 (1-2),* 239–44	2001 May
Optimisation of accelerated solvent extraction of cocaine and benzoylecgonine from coca leaves	Brachet, A.; Rudaz, S.; Mateus, L.; Christen, P.; Veuthey, J-L.	*J. Sep. Sci. 24 (10-11),* 865–873	2001 Nov

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Influence of extraction methodologies on the analysis of five major volatile aromatic compounds of citronella grass (*Cymbopogon nardus*) and lemongrass (*Cymbopogon citratus*) grown in Thailand	Chanthai, S.; Prachakoll, S.; Ruangviriyachai, C.; Luthria, D. L.	*J. AOAC Int. 95 (3),* 763–72	2012 May-Jun
Accelerated solvent extraction of vitamin K_1 in medical foods in conjunction with matrix solid-phase dispersion	Chase, G. W.; Thompson, B.	*J. AOAC Int. 83 (2),* 407–10	2000
Development of a liquid chromatography-tandem mass spectrometry with pressurized liquid extraction method for the determination of benzimidazole residues in edible tissues	Chen, D.; Tao, Y.; Zhang, H.; Pan, Y.; Liu, Z.; Huang, L.; Wang, Y.; Peng, D.; Wang, X.; Dai, M; Yuan, Z.	*J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 879 (19),* 1659–67	2011 Jun
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Optimization of accelerated solvent extraction for the determination of chlorinated pesticides from animal feed	Chen, S.; Gfrerer, M.; Lankmayr, E.; Quan, X.; Yang, F.	*Chromatographia 58,* 631–636	2003
Uptake of oxytetracycline, sulfamethoxazole and ketoconazole from fertilised soils by plants	Chitescu, C. L.; Nicolau, A. I.; Stolker, A. A.	*Food Addit. Contam. Part A Chem. Anal. Control Expo. Risk Assess. 30 (6),* 1138–46	2013
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Comparison of extraction techniques and modeling of accelerated solvent extraction for the authentication of natural vanilla flavors	Cicchetti, E.; Chaintreau, A..	*J. Sep. Sci. 32 (11),* 1957–64	2009 Jun
Development of a fast and convenient method for the isolation of triterpene saponins from *Actaea racemosa* by high-speed countercurrent chromatography coupled with evaporative light scattering detection	Cicek, S. S.; Schwaiger, S.; Ellmerer, E. P.; Stuppner, H.	*Planta. Med. 76 (5),* 467–73	2010 Mar
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Pressurized fluid extraction of carotenoids from *Haematococcus pluvialis* and *Dunaliella salina* and kavalactones from *Piper methysticum*	Denery, J. R.; Dragull, K.:Tang, C. S.; Li, Q. X.	*Anal. Chim. Acta. 501 (2),* 175–181	2004 Jan
Development and comparison of two multiresidue methods for the analysis of 17 mycotoxins in cereals by liquid chromatography electrospray ionization tandem mass spectrometry	Desmarchelier, A.; Oberson, J. M.; Tella, P.; Gremaud, E.; Seefelder, W.; Mottier, P.	*J. Agric. Food Chem. 58 (13),* 7510–9	2010 Jul
Identification, extraction and quantification of the synthetic cannabinoid JWH-018 from commercially available herbal marijuana alternatives	Dunham, S. J.; Hooker, P. D.; Hyde, R. M.	*Forensic Sci. Int. 223 (1-3),* 241–4	2012 Nov
Evaluation of polyphenol contents in differently processed apricots using accelerated solvent extraction followed by high-performance liquid chromatography-diode array detector	Erdogan, S.; Erdemoglu, S.	*Int. J. Food Sci. Nutr. 62 (7),* 729–39	2011 Nov
Determination of 2,4,6-trichloroanisole and guaiacol in cork stoppers by pressurised fluid extraction and gas chromatography–mass spectrometry	Ezquerro, Ó.; Garrido-López, Á.; Tena, M. T.	*J. Chromatogr., A. 1102 (12),* 18–24	2006 Jan
Multiwalled carbon nanotubes as matrix solid-phase dispersion extraction absorbents to determine 31 pesticides in agriculture samples by gas chromatography-mass spectrometry	Fang, G.; Min, G.; He, J.; Zhang, C.; Qian, K.; Wang, S.	*J. Agric. Food Chem. 57 (8),* 3040–5	2009 Apr
High-anthocyanin strawberries through cultivar selection	Fredericks, C. H.; Fanning, K. J.; Gidley, M. J.; Netzel, G.; Zabaras, D.; Herrington, M.; Netzel, M.	*J. Sci. Food Agric. 93 (4),* 846–52	2013 Mar
Optimal extraction and fingerprint analysis of *Cnidii fructus* by accelerated solvent extraction and high performance liquid chromatographic analysis with photodiode array and mass spectrometry detections	Gao, F.; Hu, Y.; Ye, X.; Li, J.; Chen, Z.; Fan, G.	*Food Chem. 1 141 (3),* 1962–71	2013 Dec
Simultaneous analysis of seven alkaloids in *Coptis-evodia* herb couple and Zuojin pill by UPLC with accelerated solvent extraction	Gao, X.; Yang, X. W.; Marriott, P. J.	*J. Sep. Sci. 33 (17-18),* 2714–22	2010 Sep
Determination of chromones in *Dysophylla stellata* by HPLC: method development, validation and comparison of different extraction methods	Gautam, R.; Srivastava, A.; Jachak, S. M.	*Nat. Prod. Commun. 5 (4),* 555–8	2010 Apr
Comparison of different extraction techniques for the determination of chlorinated pesticides in animal feed	Gfrerer, M.; Chen, S.; Lankmayr, E.; Xie, Q.; Yang, F.	*Anal. Bioanal. Chem. 378 (7),* 1861–1867	2004
Speciation analysis of selenium compounds in yeasts using pressurised liquid extraction and liquid chromatography–microwave-assisted digestion–hydride generation–atomic fluorescence spectrometry	Gómez-Ariza, J. L.; Caro de la Torre, M. A.; Giráldez, I.; Morales, E.	*Anal. Chim. Acta. 524, (1–2),* 305–314	2004 Oct

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Multianalysis of 35 mycotoxins in traditional Chinese medicines by ultra-high-performance liquid chromatography-tandem mass spectrometry coupled with accelerated solvent extraction	Han, Z.; Ren Y.; Zhu, J.; Cai, Z.; Chen, Y.; Luan, L.; Wu, Y.	*J. Agric. Food Chem. 60 (33),* 8233-47.	2012 Aug
Pressurized liquid extraction-capillary electrophoresis-mass spectrometry for the analysis of polar antioxidants in rosemary extracts	Herrero, M.; Arráez-Román, D.; Segura A.; Kenndler, E.; Gius, B.; Raggid, M. A.; Ibáñez, E.; Cifuentes, A.	*J. Chromatogr., A.1084 (1-2),* 54–62.	2005 Aug
Accelerated solvent extraction of alkylresorcinols in food products containing uncooked and cooked wheat	Holt, M D.; Moreau, R A,.;DerMarderosian, A.; McKeown, N.; Jacques, P. F.	*J. Agric. Food Chem. 60 (19),* 4799–802	2012 May
Application of response surface methodology to optimize pressurized liquid extraction of antioxidant compounds from sage (*Salvia officinalis* L.), basil (*Ocimum basilicum* L.) and thyme (*Thymus vulgaris* L.)	Hossain, M. B.; Brunton, N. P.; Martin-Diana, A. B.; Barry-Ryan, C.	*Food Funct. 1(3),* 269–77	2010 Dec
A review of modern sample-preparation techniques for the extraction and analysis of medicinal plants	Huie, C. W.	*Anal. Bioanal. Chem. 373 (1-2),* 23–30.	2002 May
Polychlorinated dioxins, furans, and biphenyls, and polybrominated diphenyl ethers in a U.S. meat market basket and estimates of dietary intake	Huwe, J. K.; Larsen, G. L.	*Environ. Sci. Technol. 39 (15),* 5606–5611	2005
Study of the effect of sample preparation and cooking on the selenium speciation of selenized potatoes by HPLC with ICP-MS and electrospray ionization MS/MS	Infante, H. G.; Borrego, A. A.; Peachey, E.; Hearn, R.; O'Connor, G.; Barrera, T G.; Ariza, J. L.	*J. Agric. Food Chem. 57(1),* 38–45.	2009 Jan
Pentacyclic triterpene distribution in various plants – rich sources for a new group of multi-potent plant extracts	Jäger, S.; Trojan, H.; Kopp, T.; Laszczyk, M. N.; Scheffler, A.	*Molecules. 14 (6),* 2016–31.	2009 Jun
Comprehensive multiresidue method for the simultaneous determination of 74 pesticides and metabolites in traditional Chinese herbal medicines by accelerated solvent extraction with high-performance liquid chromatography/tandem mass spectrometry	Jia, Z.; Mao, X.; Chen, K.; Wang, K.; Ji S.	*J. AOAC Int.; 93(5),* 1570–88.	2010 Sep-Oct
Gas chromatography-mass spectrometry (GC-MS) method for the determination of 16 European priority polycyclic aromatic hydrocarbons in smoked meat products and edible oils	Jira, W.; Ziegenhals, K.; Speer, K.	*Food Addit. Contam. Part A Chem. Anal. Control Expo. Risk Assess. 25 (6),* 704–13.	2008 Jun
Assessing pressurized liquid extraction for the high-throughput extraction of marine-sponge-derived natural products	Johnson, T. A.; Morgan, M. V.; Aratow, N. A.; Estee, S. A.; Sashidhara, K. V.; Loveridge, S. T.; Segraves, N L.; Crews, P.	*J. Nat. Prod. 73 (3),* 359–64.	2010 Mar
Lipophilic stinging nettle extracts possess potent anti-inflammatory activity, are not cytotoxic and may be superior to traditional tinctures for treating inflammatory disorders	Johnson, T. A.; Sohn, J.; Inman, W. D.; Bjeldanes, L. F.; Rayburn, K.	*Phytomedicine 20(2),* 143–7.	2013 Jan
Effects of solvent and temperature on pressurized liquid extraction of anthocyanins and total phenolics from dried red grape skin	Ju Z. Y.; Howard, L. R.	*J. Agric. Food Chem. 51 (18),* 5207–13.	2003 Aug

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Accelerated solvent extraction of ochratoxin A from rice samples	Juan, C.; González, L.; Soriano, J. M.; Moltó, J. C.; Mañes, J.	*J. Agric. Food Chem. 53 (24),* 9348–9351	2005
Accelerated solvent extraction of paclitaxel and related compounds from the bark of *Taxus cuspidate*	Kawamura, F.; Kikuchi, Y.; Ohira, T.; Yatagai, M.	*J. Nat. Prod. 62 (2),* 244–7.	1999 Feb
Determination of polybromodiphenyl ethers (PBDEs) in milk cream by gas chromatography-mass spectrometry	Kinani, S.; Bouchonnet, S.; Abjean, J.; Campargue, C.	*Food Addit. Contam. Part A Chem. Anal. Control Expo. Risk Assess. 25 (8),* 1007–14	2008 Aug
Determination of isoflavones in soy bits by fast column high-performance liquid chromatography coupled with UV–visible diode-array detection	Klejdus, B.; Mikelová, R.; Petrlová, J.; Potešil, D.; Adam, V.; Stiborová, J.; Hodek, P.; Vacek, J.; Kizek, R.; Kubán, V.	*J. Chromatogr., A. 1084 (1–2), 19,* 71–79	2005 Aug
Accelerated solvent extraction of lignin from *Aleurites moluccana* (candlenut) nutshells	Klein, A. P.; Beach, E. S.; Emerson, J. W.; Zimmerman, J. B.	*J. Agric. Food Chem. 58 (18),* 10045–8	2010 Sep
Application of TLC method with video scanning in estimation of daily dietary intake of specific flavonoids – preliminary studies	Koch, W.; Kukuła-Koch, W.; Marzec, Z.; Marc, D.	*Acta Pol. Pharm. 70 (4),* 611–20	2013 Jul-Aug
Evaluation of a fibrous cellulose drying agent in supercritical fluid extraction and pressurized liquid extraction of diverse pesticides	Lehotay, S. J.; Lee, C. H.	*J. Chromatogr., A.785 (1-2),* 313–27	1997 Oct
Application of accelerated solvent extraction to the investigation of saikosaponins from the roots of *Bupleurum falcatum*	Li, W.; Liu, Z.; Wang, Z.; Chen, L.; Sun, Y.; Hou, J.; Zheng, Y.	*J. Sep. Sci. 33 (12),* 1870–6	2010 Jun
Applicability of accelerated solvent extraction for synthetic colorants analysis in meat products with ultrahigh performance liquid chromatography-photodiode array detection	Liao, Q. G.; Li ,W. H.; Luo, LG.	*Anal. Chim. Acta. 716,* 128–32	2012 Feb
Extraction, isolation, and purification of analytes from samples of marine origin – a multivariate task	Liguori, L.; Bjørsvik, H. R.	*J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 910,* 46–53	2012 Dec
Investigation on levels of polybrominated diphenyl ethers in retail fish and egg products in Shenzhen	Liu, B.; Zhang, L. S.; Zhang, J. Q.; Jiang, Y. S.; Zhou, J.; Huang, H. Y.	*Zhonghua Yu Fang Yi Xue Za Zhi. 45 (12),* 1068–72	2011 Dec
Characterization of secondary volatile profiles in *Nigella sativa* seeds from two different origins using accelerated solvent extraction and gas chromatography-mass spectrometry	Liu, X.; Abd El-Aty, A. M.; Cho, S. K.; Yang, A.; Park, J. H.; Shim, J. H.	*Biomed. Chromatogr. 26 (10),* 1157–62	2012 Oct
Accelerated solvent extraction of monacolin K from red yeast rice and purification by high-speed counter-current chromatography	Liu, Y.; Guo, X.; Duan, W.; Wang, X.; Du, J.	*J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 878 (28),* 2881–5	2010 Oct
Multiresidue determination of organophosphorus pesticides in ginkgo leaves by accelerated solvent extraction and gas chromatography with flame photometric detection	Lu, Y.; Yi, X.	*J. AOAC Int. 88 (3),* 729–735	2005

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Influence of sample preparation on assay of phenolic acids from eggplant	Luthria, DL.; Mukhopadhyay, S.	*J. Agric. Food Chem. 54 (1),* 41–47	2006
Pressurised solvent extraction for organotin speciation in vegetable matrices	Marcic, C.; Lespe,s G.; Potin-Gautier, M.	*Anal. Bioanal. Chem. 382 (7),* 1574–83	2005 Aug
Comparison of different methods for the determination of the oil content in oilseeds	Matthäus, B.; Brühl, L.	*J. AOCS 78* 95–102.	2001 Jan
A comparison of automated and traditional methods for the extraction of arsenicals from fish	McKiernan, J. W.; Creed, J. T.; Brockhoff, C. A.; Caruso, J. A.; Lorenzana, R. M.	*J. Anal. At. Spectrom. 14,* 607–613	1999
Subcritical solvent extraction of anthocyanins from dried red grape pomace	Monrad, J. K.; Howard, L. R.; King, J.;, Srinivas, K.; Mauromoustakos, A.	*J. Agric. Food Chem. 58 (5),* 2862–8	2010 Mar
Subcritical solvent extraction of procyanidins from dried red grape pomace	Monrad, J. K.; Howard, L. R.; King, J. W.; Srinivas, K.; Mauromoustakos, A.	*J. Agric. Food Chem.58 (7),* 4014–21	2010 Apr
Pressurized liquid extraction of polar and nonpolar lipids in corn and oats with hexane, methylene chloride, isopropanol, and ethanol	Moreau, R. A.; Powell, M. J.; Singh, V.	*J. Oil Fat Industr. 80 (11),* 1063–1067	2003 Jan
Accelerated solvent extraction for natural products isolation	Mottaleb, M. A.; Sarker, S. D.	*Methods Mol. Biol. 864,* 75–87	2012
Optimization of extraction process for phenolic acids from black cohosh (*Cimicifuga racemosa*) by pressurized liquid extraction	Mukhopadhyay, S,.;Luthria, D. L,.;Robbins, R. J.	*J. Sci. Food Agric. 86 (1),* 156–162, 15	2006 Jan
Anxiolytic activity of a supercritical carbon dioxide extract of *Souroubea sympetala* (Marcgraviaceae)	Mullally, M.; Kramp, K.; Cayer, C.; Saleem, A.; Ahmed, F, McRae, C.; Baker, J.; Goulah, A.; Otorola, M.; Sanchez, P.; Garcia, M.; Poveda, L.; Merali, Z.; Durst, T.; Trudeau, V. L.; Arnason, J. T.	*Phytother. Res. 25 (2),* 264–70	2011 Feb
On-line clean-up of pressurized liquid extracts for the determination of polychlorinated biphenyls in feedingstuffs and food matrices using gas chromatography–mass spectrometry	Müller, A.; Björklund, E.; von Holst, C.	*J. Chromatogr., A. 925 (1–2),* 197–205	2001 Aug
Analysis of multiple herbicides in soybeans using pressurized liquid extraction and capillary electrophoresis	Nemoto, S.; Lehotay, S. J.	*J. Agric. Food Chem.; 46 (6),* 2190–2199	1998
Comparison of sample preparation methods, validation of an UPLC-MS/MS procedure for the quantification of tetrodotoxin present in marine gastropods and analysis of pufferfish	Nzoughet, J. K.; Campbell, K.; Barnes, P.; Cooper, K. M.; Chevallier, O. P, Elliott, C. T.	*Food Chem. 15; 136 (3-4),* 1584–9	2013 Feb
Multiresidue analysis of pesticides in vegetables and fruits using two-layered column with graphitized carbon and water absorbent polymer	Obana, H.; Akutsu, K.; Okihashi, M.; Hori, S.	*The Analyst 123,* 711–714	1998
Analysis of 2-alkylcyclobutanones with accelerated solvent extraction to detect irradiated meat and fish	Obana, H.; Furuta, M.; Tanaka, Y.	*J. Agric. Food Chem. 53 (17),* 6603–8	2005 Aug

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Determination of organophosphorus pesticides in foods using an accelerated solvent extraction system	Obana, H.; Kikuchi, K.; Okihashi, M.; Hori, S.	*Analyst 122 (3),* 217–20	1997 Mar
Pressurized hot water extraction of berberine, baicalein and glycyrrhizin in medicinal plants	Ong, E. S.; Shea Mei, L.	*Anal. Chim. Acta. 482 (1),* 81–89	2003 Apr
Pressurized liquid extraction of berberine and aristolochic acids in medicinal plants	Ong E. S.; Woo S. O.; Yong, Y. K.	*J. Chromatogr., A. 904 (1),* 57–6422	2000 Dec
Rapid determination of pesticide multiresidues in vegetables and fruits by accelerated solvent extraction coupled with online gel permeation chromatography-gas chromatography-mass spectrometry	Ouyang, Y.; Tang, H.; Wu, Y.; Li, G.	*Se Pu. 30(7),* 654–9	2012 Jul
Determination of zearalenone from wheat and corn by pressurized liquid extraction and liquid chromatography-electrospray mass spectrometry	Pallaroni, L.; von Holst, C.	*J. Chromatogr., A. 993,* 39–45	2003
Development of an extraction method for the determination of zearalenone in corn using less organic solvents	Pallaroni, L.; von Holst, C.	*J. Chromatogr., A. 5 1055 (1-2),* 247–9	2004 Nov
Stability of phenolic compounds during extraction with superheated solvents	Palma, M.; Piñeiro, Z.; Barroso, C. G.	*J. Chromatogr., A. 6 921 (2),* 169–74	2001 Jul
Extraction and analysis of trace amounts of cyclonite (RDX) and its nitroso-metabolites in animal liver tissue using gas chromatography with electron capture detection (GC-ECD)	Pan, X.; Zhang, B.; Cobb, G. P.	*Talanta 67 (4),* 816–23	2005 Oct
Simultaneous determination of 405 pesticide residues in grain by accelerated solvent extraction then gas chromatography-mass spectrometry or liquid chromatography-tandem mass spectrometry	Pang, G.; Liu, Y.; Fan, C.; Zhang, J.; Cao, Y.; Li, X.; Li, Z.; Wu, Y.; Guo, T.	*Anal. Bioanal. Chem. 384,* 1366–1408	2006 Mar
Automated sample preparation by pressurized liquid extraction-solid-phase extraction for the liquid chromatographic-mass spectrometric investigation of polyphenols in the brewing process	Papagiannopoulos, M.; Mellenthin, A.	*J. Chromatogr., A. 8 976 (1-2),* 345–8	2002 Nov
Online coupling of pressurized liquid extraction, solid-phase extraction and high-performance liquid chromatography for automated analysis of proanthocyanidins in malt	Papagiannopoulos, M.; Zimmermann, B.; Mellenthin, A.; Krappe, M.; Maio, G.; Galensa, R.	*J. Chromatogr., A. 7 958 (1-2),* 9–16	2002 Jun
Simultaneous determination of 13 quinolones from feeds using accelerated solvent extraction and liquid chromatography	Pecorelli, I.; Galarini, R.; Bibi, R.; Floridi, A. I.; Casciarri, E.; Floridi, A.	*Anal. Chim. Acta. 483 (1-2),* 81–89	2003 April
Comparison of soxhlet, ultrasound-assisted and pressurized liquid extraction of terpenes, fatty acids and Vitamin E from *Piper gaudichaudianum* Kunth	Péres, V. F.; Saffi, J.; Melecchi, M. I.; Abad, F. C.; de Assis Jacques, R.; Martinez, M. M.; Oliveira, E. C.; Caramão, E. B.	*J. Chromatogr., A. 1105 (1-2),* 115–8	2006 Feb
Pressurised fluid extraction (PFE) as an alternative general method for the determination of pesticide residues in rape seed	Pihlström, T.; Isaac, G.; Waldebäck, M.; Osterdahl, B. G.; Markides, K. E.	*Analyst 127 (4),* 554–9	2002 Apr
Determination of catechins by means of extraction with pressurized liquids	Piñeiro, Z.; Palma, M.; Barroso C. G.	*J. Chromatogr., A. 13 1026 (1-2),* 19–23.	2004 Feb

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An improved clean-up strategy for simultaneous analysis of polychlorinated diben-zo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), and polychlorinated biphenyls (PCB) in fatty food samples	Pirard, C.; Focant, J. F.; De, P. E.	*Anal. Bioanal. Chem. 372 (2),* 373–81.	2002 Jan
Extraction of polar and hydrophobic pollutants using accelerated solvent extraction (ASE)	Pörschmann, J., Plugge, J.	*Fresen. J. Anal. Chem. 364 (7),* 643–645	1999
Quantification of the total amount of artemisinin in leaf samples by thin layer chromatography	Quennoz, M.; Bastian, C.; Simonnet, X.; Grogg, A. F.	*Chimia (Aarau) 64 (10),* 755–7.	2010
Determination of fat in dairy products using pressurized solvent extraction	Richardson, R. K.	*J. AOAC Int. 84 (5),* 1522–1533	2001
Influence of altitudinal variation on the content of phenolic compounds in wild populations of *Calluna vulgaris,* Sambucus nigra, and *Vaccinium myrtillus*	Rieger, G.; Müller, M.; Guttenberger, H.; Bucar, F.	*J. Agric. Food Chem. 56 (19),* 9080–6.	2008 Oct
Pressurized liquid extraction of isoflavones from soybeans	Rostagno, M. A.; Palma, M.; Barroso, C. G.	*Anal. Chim. Acta. 522 (2),* 169–177.	2004 Sep
A multi-residue method for the analysis of organophosphorus residues in cooked and polished rice using accelerated solvent extraction and dispersive-solid phase extraction (D-SPE) technique and uncertainty measurement	Sanyal, D.; Rani, A.; Alam, S.	*J. Environ. Sci. Health, B 44 (7),* 706–16.	2009 Sep
Accelerated solvent extraction of lipids for determining the fatty acid composition of biological material	Schäfer, K.	*Anal. Chim. Acta. 358 (1),* 69–77	1998 Jan
HPLC analysis of kaempherol and quercetin derivatives isolated by different extraction techniques from plant matrix	Skalicka-Wozniak, K.; Szypowski, J.; Głowniak, K.	*J. AOAC Int. 94 (1),* 17–21.	Jan-Feb 2011
Statistical evaluation of fatty acid profile and cholesterol content in fish (common carp) lipids obtained by different sample preparation procedures	Spiric, A.; Trbovic, D.; Vranic, D.; Djinovic, J.; Petronijevic, R.; Matekalo-Sverak, V.	*Anal. Chim. Acta. 672 (1-2), 66–71.*	2010 Jul
Application of accelerated solvent extraction in the analysis of organic contaminants, bioactive and nutritional compounds in food and feed	Sun, H.; Ge, X.; Lv, Y.; Wang, A.	*J. Chromatogr., A. 1237,* 1–23.	2012 May
Development of an accelerated solvent extraction, ultrasonic derivatisation LC-MS/MS method for the determination of the marker residues of nitrofurans in freshwater fish	Tao, Y.; Chen, D.; Wei, H.; Yuanhu, P.; Liu, Z.; Huang, L.; Wang, Y.; Xie, S.; Yuan, Z.	*Food Addit. Contam. Part A Chem. Anal. Control Expo. Risk Assess. 29 (5),* 736–45.	2012
Simultaneous determination of lincomycin and spectinomycin residues in animal tissues by gas chromatography-nitrogen phosphorus detection and gas chroma-tography-mass spectrometry with accelerated solvent extraction	Tao, Y.; Chen, D.; Yu, G,.;Yu, H.; Pan, Y.; Wang, Y.; Huang, L.; Yuan, Z.	*Food Addit. Contam. Part A Chem. Anal. Control Expo. Risk Assess. 28 (2),* 145–54.	2011 Feb
Determination of 17 macrolide antibiotics and avermectins residues in meat with accelerated solvent extraction by liquid chromatography-tandem mass spectrometry	Tao, Y.; Yu, G.; Chen, D.; Pan, Y.; Liu, Z.; Wei, H.; Peng, D.; Huang, L.; Wang, Y.; Yuan, Z.	*J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 897,* 64–71.	2012 May
Determination of seven toxaphene congeners in ginseng and milkvetch root by gas chromatography tandem mass spectrometry	Tian, S.; Mao, X.; Miao, S.; Jia, Z.; Wang, K.; Ji, S.	*Se Pu. 30 (1),* 14–20.	2012 Jan

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A consecutive preparation method based upon accelerated solvent extraction and high-speed counter-current chromatography for isolation of aesculin from *Cortex fraxinus*	Tong, X.; Zhou, T, Xiao, X.; Li, G.	*J. Sep. Sci. 35 (24),* 3609–14	2012 Dec
Characterization of anthocyanins and anthocyanidins in purple-fleshed sweetpotatoes by HPLC-DAD/ESI-MS/MS	Truong, V. D.; Deighton, N.; Thompson, R. T.; McFeeters, R. F.; Dean, L. O.; Pecota, K. V.; Yencho, G. C.	*J. Agric. Food Chem. 58 (1),* 404–10	2010 Jan
Fat extraction from acid- and base-hydrolyzed food samples using accelerated solvent extraction	Ullah, S. M.; Murphy, B.; Dorich, B.; Richter, B.; Srinivasan, K.	*J. Agric. Food Chem. 59 (6),* 2169–74.	2011 Mar
Analysis of zearalenone in cereal and swine feed samples using an automated flow-through immunosensor	Urraca, J. L.; Benito-Peña, E.; Pérez-Conde, C.; Moreno-Bondi, M. C.; Pestka, J. J.	*J. Agric. Food Chem. 53 (9),* 3338–3344	2005
Accelerated solvent extraction and gas chromatography/mass spectrometry for determination of polycyclic aromatic hydrocarbons in smoked food samples	Wang, G.; Lee, A. S.; Lewis, M.; Kamath, B.; Archer, R. K.	*J. Agric. Food Chem. 47 (3),* 1062–6.	1999 Mar
Subcritical water extraction of alkaloids in *Sophora flavescens* Ait. and determination by capillary electrophoresis with field-amplified sample stacking	Wang, H.; Lu, Y.; Chen, J.; Li, J.; Liu, S.	*J. Pharm. Biomed .Anal. 58,* 146–51.	2012 Jan
Evaluation of Soxhlet extraction, accelerated solvent extraction and microwave-assisted extraction for the determination of polychlorinated biphenyls and polybrominated diphenyl ethers in soil and fish samples	Wang, P.; Zhang, Q.; Wang, Y.; Wang, T.; Li X.; Ding, L.; Jiang, G.	*Anal. Chim. Acta. 663 (1),* 43–8.	2010 Mar
Determination of ten pesticides of pyrazoles and pyrroles in tea by accelerated solvent extraction coupled with gas chromatography-tandem mass spectrometry	Xu, D.; Lu, S.; Chen, D.; Lan, J.; Zhang, Z.; Yang, F.; Zhou, Y.	*Se Pu.; 31 (3),* 218–22.	2013 Mar
Online cleanup of accelerated solvent extractions for determination of adenosine 5'-triphosphate (ATP), adenosine 5'-diphosphate (ADP), and adenosine 5'-monophosphate (AMP) in royal jelly using high-performance liquid chromatography	Xue, X.; Wang, F.; Zhou, J.; Chen, F.; Li, Y.; Zhao, J.	*J. Agric. Food Chem. 57 (11),* 4500–5.	2009 Jun
Identification and quantitation of eleven sesquiterpenes in three species of *Curcuma* rhizomes by pressurized liquid extraction and gas chromatography–mass spectrometry	Yang, F. Q.; Li ,S.; Chen, Y.; Lao, S. C.; Wang, YT.; Dong, T. T. X.; Tsim, K. W. K.	*J. Pharm. Biomed. Anal. 39 (3/4),* 552–558	2005 Sep
Dispersive solid-phase extraction cleanup combined with accelerated solvent extraction for the determination of carbamate pesticide residues in *Radix glycyrrhizae* samples by UPLC-MS-MS	Yang, R. Z.; Wang, J. H.; Wang, M. L.; Zhang, R.; Lu, X. Y.; Liu, W. H.	*J. Chromatogr. Sci. 49 (9),* 702–8.	2011 Oct
Simultaneous determination of amitraz and its metabolite residue in food animal tissues by gas chromatography-electron capture detector and gas chromatography-mass spectrometry with accelerated solvent extraction	Yu, H.; Tao, Y.; Le, T.; Chen, D.; Ishsan, A.; Liu, Y, Wang, Y.; Yuan, Z.	*J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 878 (21),* 1746–52.	2010 Jul
Simultaneous determination of fluoroquinolones in foods of animal origin by a high performance liquid chromatography and a liquid chromatography tandem mass spectrometry with accelerated solvent extraction	Yu, H.; Tao, Y.; Chen, D.; Pan, Y.; Liu, Z.; Wang, Y.; Huang, L.; Dai, M.; Peng, D.; Wang, X.; Yuan, Z.	*J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 885-886,* 150–9.	2012 Feb

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Determination of pentachlorophenol residue in meat and fish by gas chromatography-electron capture detection and gas chromatography-mass spectrometry with accelerated solvent extraction	Zhao, D.	*J. Chromatogr. Sci.*	2013 May
Response surface modeling and optimization of accelerated solvent extraction of four lignans from *fructus schisandrae*	Zhao, L. C.; He, Y, Deng.; X, Yang, G. L.; Li, W.; Liang, J.; Tang, Q. L.	*Molecules. 17 (4),* 3618–29	2012 Mar
Determination of acetanilide herbicides in cereal crops using accelerated solvent extraction, solid-phase extraction and gas chromatography-electron capture detector	Zhang, Y.; Yang, J.; Shi, R.; Su, Q.; Yao, L.; Li, P.	*J. Sep. Sci. 34 (14),* 1675–82	2011 Jul
Application of accelerated solvent extraction coupled with high-performance counter-current chromatography to extraction and online isolation of chemical constituents from *Hypericum perforatum* L	Zhang, Y.; Liu, C.; Yu, M.; Zhang, Z.; Qi, Y.; Wang, J.; Wu, G.; Li, S.; Yu, J.; Hu, Y.	*J. Chromatogr., A. 1218 (20),* 2827–34	2011 May
Analysis of volatile components in Qingshanlvshui tea using solid-phase microextraction/accelerated solvent extraction-gas chromatography-mass spectrometry	Zhan, J.; Lu, S.; Meng, Z.; Xiang, N.; Cao, Q.; Miao, M.	*Se Pu. 26 (3),* 301–5.	2008 May

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Technical Collateral: Sample Preparation Methods

Product Number	Technique	Title
AN 326	HPLC-UV	Extraction of Drugs from Animal Feeds Using Accelerated Solvent Extraction (ASE)
AN 335	HPLC-UV	Accelerated Solvent Extraction (ASE) of Active Ingredients from Natural Products
AN 356	IC-conductivity	Determination of Perchlorate in Vegetation Samples Using Accelerated Solvent Extraction and Ion Chromatography
AN 357	HPLC	Extraction of Phenolic Acids from Plant Tissue Using Accelerated Solvent Extraction (ASE)
AN 363	HPLC	Extraction of Herbal Marker Compounds Using Accelerated Solvent Extraction Compared to Traditional Pharmacopoeia Protocols

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AI71478-EN 08/16S