Recent Evolution of Monographs for Dietary Supplements in USP

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Documentary Standards Development USP
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About USP
USP—Founded in 1820

- Founded by eleven medical visionaries in 1820
- Intended to promote drug standardization and better communication between physicians and pharmacists
- An important milestone in American medicine and pharmacy
To promote the public health and benefit practitioners and patients by disseminating authoritative standard and information developed by its volunteers for medicines, other healthcare technologies, and related practices used to maintain and improve health and promote optimal healthcare delivery.
USP’s Structure

- Not-for-profit organization—501(C)(3)
- Independent and non-governmental
- Expert knowledge base—scientific activities guided by volunteer experts from different areas of healthcare
- Since 2010 FDA Liaisons participate in Expert Committees
Sponsor submits Request for Revision (RR) to USP

Scientific Liaison approves RR for publication in *Pharmacopeial Forum*

Scientific Liaison requests further information or revision for the Request for Revision

Public comments received on RR from *Pharmacopeial Forum* (90 days)

Expert Committees reviews comments and accepts or rejects them, and possibly alters RR text as it deems appropriate

(Not Approved)
Expert Committee determines that republishing the revised RR in *Pharmacopeial Forum* is necessary (due to nature or significance of comments)

Comments and responses published with RR in *Pharmacopeial Forum*

(Approved)
Request for Revision (with possible alterations) becomes effective and is published in the next USP publication. The comments and responses are posted on the USP “commentary section” of USP website.
Setting Standards for Dietary Supplements
**Federal Food, Drug, and Cosmetic Act**
Sections 201 (g) and (j), 501(b), 502(g)
*Official compendia* standards FDA enforceable for all drugs.
*Conformance generally not optional.*

**Dietary Supplement Health & Education Act (DSHEA)**
Section 403(s)(2)(D) of the FD&C Act
A dietary supplement represented as conforming to *Official Compendia* specifications shall be deemed misbranded if it fails to do so.

*Conformance is optional.*
Historical Perspective of USP Standards for Dietary Supplements

1820-1900

USP’s standards compendium included only natural medicines. e.g. Chamomile, Valerian, and Ginger

1820-1940

USP developed over 600 botanical monographs

1942

USP monographs for single ingredient vitamins. Surge of synthetic small molecule drugs, gradual omission of botanical monographs from pharmacopeias.

1995
In response to DSHEA, USP explored the feasibility of establishing standards and information for botanical and non-botanical Dietary Supplements with a GMP General Chapter.

USP 27–NF 22 includes a dietary supplements section separated from drug standards +200 monographs for botanicals, non-botanicals, and vitamin-mineral combination products covering ~900 dietary supplement.
Continuing the Timeline
USP Standards for Dietary Supplements

2009

2009 NEW USP DIETARY SUPPLEMENTS COMPENDIUM
All USP Dietary Supplement Monographs and relevant General Chapters plus authorized information published in a separate book.

2012

2012 FIRST REVISION USP DIETARY SUPPLEMENTS COMPENDIUM
50 new Dietary Supplement Monographs
560 Monographs all redesigned
160 excipients used in DS
26 Safety reviews
Expanded authorized information
Content for the USP Dietary Supplements Compendium

- General Notices and Requirements
- US Pharmacopeia Dietary Supplement Monographs
- US Pharmacopeia General Chapters Related to DS
- FCC Relevant Monographs
- FCC General Chapters
- Reagents and Tables
- Photographs and Diagrams to Aid Macroscopic and Microscopic Descriptions
- Reference Chromatograms (TLC and HPLC)
- Chemical Structures of Relevant Constituents
- Current Recommendations for Daily Intake from Recognized Organizations
- Safety Review Protocol and Safety Evaluations
- USPC Verification Programs for Dietary Supplements
- Dietary Supplements Regulatory Framework
- Guidance Documents
Increased education/awareness of industry about USP, to promote further implementation of standards

Increased media presence

e-news letters

Free access to PF

Compendial Updates
Old Monographs
New Monographs
ZINGIBER

Ginger
Zingib.

Ginger is the dried rhizome of *Zingiber officinale* Roscoe (Fam. Zingiberaceae), known in commerce as Jamaica Ginger, Cochin Ginger, and African Ginger. The outer cortical layers are often either partially or completely removed.

Ginger yields not less than 2 per cent of non-volatile ether-soluble extractive and not less than 12 per cent of cold water-extractive.
Description and physical properties.

Unground Jamaica Ginger—Rhizome horizontal, laterally compressed, irregularly branched, from 4 to 16 cm. in length and from 4 to 20 mm. in thickness; the cork wholly removed; externally light brown, longitudinally striate, ends of the branches with depressed stem-scars; fracture short, fibrous, starchy and resinous; internally yellowish to light brown; odor agreeably aromatic; taste aromatic and pungent.

Unground Cochin Ginger—Cork almost or wholly removed on the flattened sides light brown to grayish-yellow, fracture shorter, less fibrous and more starchy than other varieties; internally yellowish-white; oil and resin cells vary from yellowish to brownish-red; odor aromatic, taste pungent.

Unground African Ginger—Cork partly removed on the flattened sides, leaving light brownish areas; portions with cork, longitudinally or reticulately wrinkled and grayish-brown; internally light yellow to brown; taste aromatic and strongly pungent; otherwise resembling Jamaica Ginger.

Structure—Chiefly thin-walled, starch-bearing parenchyma cells, numerous scattered secretion cells and small vascular bundles; the latter very numerous, adjacent to the inner face of the narrow endodermis, the latter separating the thin cortex from the central cylinder; secretion cells, similar in size and shape to the parenchyma cells and with yellowish or orange-colored oil or oleoresin or reddish-brown resin; vascular bundles collateral, with few trachea, small phloem cells and usually accompanied by fibers lying on the inner face or completely surrounding the vascular tissues; cork of several or many rows of cells in African Ginger and Cochin Ginger.
Ginger monograph in the 1950’s

Assay—Place 4 Gm. of ground Ginger in a 200 cc. flask, fill to the mark with distilled water, and agitate at half-hour intervals during eight hours. Then allow the mixture to stand for sixteen hours and filter. Evaporate 50 cc. of the filtrate, representing 1 Gm. of the drug, on a water bath, dry to constant weight at 100° C., and weigh. It yields not less than 12 percent of cold water-extractive.

For non-volatile ether-soluble extractive, proceed as directed on page 466.

Preparations—Fluidextractum Zingiberis, Pulvis Rhei Compositus, Syrupus Zingiberis (from Fluidextract), Tinctura Zingiberis.

AVERAGE DOSE—Metric, 0.5 Gm.—Apothecaries, 8 grains.
Ginger

Ginger is the dried rhizome of *Zingiber officinale* Roscoe (Fam. Zingiberaceae), scraped, partially scraped, or unscraped. It is known in commerce as unbleached ginger.

Packaging and storage—Preserve in well-closed containers, protected from light and moisture, and store in a cool area.

Labeling—The label states the Latin binominal and, following the official name, the part of the plant contained in the article.

USP Reference standards (11)—
USP Capsaicin RS
USP Ginger Constituent Mixture RS
USP Powdered Ginger RS

Botanic characteristics—

Macroscopic—Ginger occurs in horizontal, laterally flattened, sympodially branching pieces. Whole rhizomes are 5 to 15 cm long, 1.5 to 6 cm wide, and up to 2 cm thick, sometimes split

Histology—The scraped rhizome in transverse section shows a cortex composed of multiple layers of parenchyma cells rich in simple, large, flattened, ovoid or sack-shaped starch granules, 5 to 15 μm wide and 30 to 60 μm long having an eccentric hilum, some showing faint transverse striations. The cortex also
Identification—

A:  Pulverize about 5 g of Ginger. To about 1 g of the pulverized Ginger add 5 mL of dilute acetic acid, prepared by diluting 1 part of glacial acetic acid with 1 part of water, and shake for 15 minutes. Filter, and add a few drops of ammonium oxalate TS to the filtrate: not more than a slight turbidity is produced.

B:  Dissolve about 50 mg of the residue obtained in the test for Alcohol-soluble extractives in 25 mL of water, and extract this solution with two 15-mL portions of ether. Combine the ether extracts, and evaporate in a porcelain dish. To the residue so obtained, add 5 mL of sulfuric acid solution (7.5 in 10.0) and about 5 mg of vanillin. Allow to stand for 15 minutes, and add an equal volume of water: the solution turns azure blue.

C:  Thin-Layer Chromatographic Identification Test (201)—

   Adsorbent:  0.50-mm layer of chromatographic silica gel mixture.
Microbial enumeration (2021)—The total bacterial count does not exceed $10^3$ cfu per g. The total combined molds and yeasts count does not exceed $10^3$ cfu per g, the bile-tolerant Gram-negative bacteria count does not exceed $10^3$ cfu per g, and it meets the requirements of the tests for absence of Salmonella species and Escherichia coli.

Total ash (561): not more than 8.0%.

Acid-insoluble ash (561): not more than 2.0%.

Water-soluble ash (561): not less than 1.9%.

Water, Method Ia (921): not more than 10%.

Alcohol-soluble extractives, Method 2 (561)—Collect the filtrate in a 100-mL volumetric flask, dilute with alcohol to volume, and mix. Evaporate 50 mL of the filtrate at a temperature not exceeding $90^\circ$C; not less than 4.5% residue is found. Save the residue for use in Identification test B and the remaining volume of the filtrate for the tests for Limit of shogaols and Content of gingerols and gingerdiones.

Water-soluble extractives, Method 2 (561): not less than 10.0%.

Foreign organic matter (561): not more than 1.0%.

Volatile oil content (561): not less than 1.8 mL per 100 g.

Pesticide residues (561): meets the requirements.

Content of starch, Method 1 (561): not less than 42%, Method Ia of the General Procedures being used.

Limit of shogaols—From the chromatograms obtained in the test for Content of gingerols and gingerdiones, calculate the sum of the peak responses due to shogaols, occurring at about the following retention times, relative to 1.0 for capsaicin: 1.9 for 6-
Content of gingerols and gingerdiones—

Solution A—Prepare a filtered and degassed mixture of acetonitrile, dilute phosphoric acid (1 in 1000), and methanol (55:44:1).

Solution B—Use filtered and degassed acetonitrile.

Mobile phase—Use variable mixtures of Solution A and Solution B as directed for Chromatographic system. Make adjustments if necessary (see System Suitability under Chromatography (621)).

Standard preparation—Dissolve an accurately weighed quantity of USP Capsaicin RS in methanol to obtain a solution having a known concentration of about 0.1 mg per mL.

Test preparation—Use the filtrate retained from the test for Alcohol-soluble extractives.

System suitability solution—Reconstitute the content of 1 vial of USP Ginger Constituent Mixture RS in 1 mL of the Standard preparation.

Chromatographic system (see Chromatography (621))—The liquid chromatograph is equipped with a 282-nm detector and a 4.6-mm x 25-cm column that contains packing L1. The flow rate is about 1.0 mL per minute. The chromatograph is programmed as follows.
Monograph Redesign

- Tests grouped by categories
  - Definition
  - Identification
  - Assay and Strength
  - Composition
  - Purity (contaminants and adulterants)
  - Specific tests
  - Performance of Dosage Forms: Dissolution/Disintegration

- Headings for Tests, Procedures, and Acceptance Criteria

- Procedure instructions simplified and more flexible
Ginger

DEFINITION
Ginger is the dried rhizome of Zingiber officinale Roscoe (Fam. Zingiberaceae), scraped, partially scraped, or un-scraped. It is known in commerce as unbleached ginger.

IDENTIFICATION
• A.
  Analysis: Pulverize 5 g of Ginger. To 1 g of the pulverized Ginger add 5 mL of dilute acetic acid, prepared by diluting 1 part of glacial acetic acid with 1 part of water, and shake for 15 min. Filter, and add a few drops of ammonium oxalate TS to the filtrate.
  Acceptance criteria: NMT a slight turbidity is produced.
C. Thin-Layer Chromatographic Identification Test

Standard solution A: Proceed as directed for the Sample solution, except to use 0.2 g of USP Powdered Ginger RS.

Standard solution B: Use the System suitability solution, prepared as directed in the test for Content of Gingerols and Gingerdiones.

Sample solution: Pulverize 5 g of Ginger. Transfer 0.2 g of pulverized Ginger to a test tube, add 5 mL of methanol, shake for 30 min, and centrifuge. Apply the supernatant to the plate.

Adsorbent: 0.50-mm layer of chromatographic silica gel mixture

Application volume: 20 μL for the Sample solution and Standard solution A; 40 μL for Standard solution B

Developing solvent system: Ether and hexanes (7:3)

Spray reagent: 10% sulfuric acid in alcohol

Analysis

Samples: Standard solution A, Standard solution B, and Sample solution

Proceed as directed in the chapter. Examine the plate under UV light at 254 nm. Spray the plate with Spray reagent, heat at 100°–105° for 10 min, and examine under daylight.

Acceptance criteria: The chromatogram of the Sample solution exhibits a spot due to gingerols that occurs at an Rf value of 0.2. A spot of shogaols may occur at an Rf value of 0.4, corresponding to those shown in the chromatogram of Standard solution B. [NOTE—The chromatograms of the Sample solution and Standard solution A may exhibit other spots in the upper region and at the origin of the plate.]
COMPOSITION

- **CONTENT OF GINGEROLS AND GINGERDIONES**
  - Solution A: Acetonitrile, dilute phosphoric acid (1 in 1000), and methanol (55:44:1)
  - Solution B: Acetonitrile
  - Mobile phase: Use Solution A for NLT seven times the retention time of capsaicin.
  - Column washing: After each chromatographic run, wash the column, using Table 1.

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<th>Time (min)</th>
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<th>Solution B (%)</th>
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<td>29</td>
<td>100</td>
<td>0</td>
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</table>
Standard solution: 0.1 mg/mL of USP Capsaicin RS in methanol
System suitability solution: Reconstitute the content of 1 vial of USP Ginger Constituent Mixture RS in 1 mL of the Standard solution.
Sample solution: Use the filtrate retained from the test for Articles of Botanical Origin, Alcohol-Soluble Extractives.

Chromatographic system
(See Chromatography (621), System Suitability.)
Mode: LC
Detector: UV 282 nm
Column: 4.6-mm x 25-cm; packing L1
Flow rate: 1 mL/min
Injection size: 25 µL

System suitability
Samples: Standard solution and System suitability solution
[Note—The relative retention times for 6-gingerol, capsaicin, and 6-shogaol are about 0.8, 1.0, and 1.9, respectively, System suitability solution.]

Suitability requirements
Resolution: NLT 3.0 between the 6-gingerol and capsaicin peaks and NLT 10.0 between the capsaicin and 6-shogaol peaks, System suitability solution
Tailing factors: NMT 2.0 for the 6-gingerol, capsaicin, and 6-shogaol peaks, System suitability solution
Relative standard deviation: NMT 2.5%, Standard solution
Analysis
Samples: Standard solution, Sample solution, and System suitability solution

Calculate the sum of the peak responses due to gingerols and gingerdiones occurring at about the following retention times, relative to 1.0 for capsaicin: 0.8 for 6-gingerol, 1.5 for 8-gingerol A, 2.2 for 8-gingerol B, 2.5 for 6-gingerdiol, 2.6 for 6-gingerdione, 3.4 for 10-gingerol, and 5.2 for 8-gingerdione.

Calculate the percentage of gingerols and gingerdiones in the sample taken:

\[ \text{Result} = \left( \frac{r_T}{r_S} \right) \times \left( \frac{C_S}{W} \right) \times 10 \]

- \( r_T \) = sum of the peak responses for gingerols and gingerdiones from the Sample solution
- \( r_S \) = peak response of capsaicin from the Standard solution
- \( C_S \) = concentration of USP Capsaicin RS in the Standard solution (mg/mL)
- \( W \) = weight of Ginger used in the test for Articles of Botanical Origin, Alcohol-Soluble Extractives (g)

Acceptance criteria: NLT 0.8%
CONTAMINANTS
- **ARTICLES OF BOTANICAL ORIGIN, Pesticide Residues (561):** Meets the requirements
- **MICROBIAL ENUMERATION TESTS (2021):** The total bacterial count does not exceed $10^3$ cfu/g; the total combined molds and yeasts count does not exceed $10^3$ cfu/g; the bile-tolerant Gram-negative bacteria count does not exceed $10^3$ cfu/g.
- **ABSENCE OF SPECIFIED MICROORGANISMS (2022):** It meets the requirements of the tests for absence of *Salmonella* species and *Escherichia coli*.

SPECIFIC TESTS
- **BOTANIC CHARACTERISTICS**
  Macroscopic: Ginger occurs in horizontal, laterally flattened, sympodially branching pieces. Whole rhizomes
- **LIMIT OF SHOGAOLS**
  Analysis: From the chromatograms obtained in the test for *Content of Gingerols and Gingerdiones*, calculate the sum of the peak responses due to shogaols, occurring at the following retention times, relative to 1.0 for capsaicin: 1.9 for 6-shogaol, 4.2 for 8-shogaol, and 5.8 for 10-shogaol.
  Calculate the percentage of shogaols in the portion taken:

  \[
  \text{Result} = \left( \frac{r_f}{r_s} \right) \times \left( \frac{C_s}{W} \right) \times 10
  \]
Ginger monograph in USP Dietary Supplement Compendium

Ginger

BOTANIC CHARACTERISTICS

a. Macroscopic Description

Fig. 1 Dried rhizome of Zingiber officinale Roscoe
b. Microscopic Description

b-1. Transverse section of rhizome

Fig. 2 Microscopic features of transverse section of *Zingiber officinale* Roscoe rhizome
A. Sketch  B. Illustration of transverse section  C. Magnification showing endodermis and vascular bundles

Fig. 3 Microscopic features of powder of *Zingiber officinale* Roscoe rhizome

a. Features under a light microscope  b. Features under a polarizing microscope
CHEMICAL CHARACTERISTICS

a. Chemical Structures

Fig. 4 Constituents of *Zingiber officinale* Roscoe rhizome
b. Thin Layer Chromatography

Fig. 5 Typical chromatograms

Track assignment: 1) USP Ginger Constituents Mixture RS (6-gingerol and 6-shogaol with increasing Rf); 2) USP Powdered Ginger RS; 3) ginger rhizomes (commercial sample); 5) powdered ginger rhizomes (commercial sample A); 6) powdered ginger rhizomes (commercial sample B)
c. High Performance Liquid Chromatography

**Content of gingerols and gingerdiones/Limit of shogaols**

![Chromatogram](image)

**Fig. 7** Typical chromatogram of Test solution

<table>
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<th>Solutions preparation:</th>
<th>according to the monograph</th>
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<tr>
<td>Column:</td>
<td>L1, 25-cm × 4.6-mm, 5-µm, Hypersil ODS, Alltech</td>
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<tr>
<td>Mobile phase:</td>
<td>acetonitrile, dilute phosphoric acid (0.1 % in water), and methanol (55:44:1) (Solution A) and acetonitrile (Solution B)</td>
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<tr>
<td>Elution:</td>
<td>isocratic with gradient wash, see below</td>
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<tr>
<td>Flow rate:</td>
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<tr>
<td>Temperature:</td>
<td>25°C</td>
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<tr>
<td>Injection volume:</td>
<td>25 µL</td>
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<tr>
<td>Detection:</td>
<td>UV, 282 nm</td>
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What’s in a USP Supplement Monograph

- Official and validated tests
- Analytical methods
- Criteria to define the
  - Identity
  - Content
  - Quality
  - Purity
## USP Dietary Supplement Monographs

<table>
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<th>Test</th>
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<th>Minerals</th>
<th>Non Botanicals</th>
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Setting Standards for Dietary Supplements: Problems and Solutions
Dissolution of Soft Shell Capsules

- Traditional Dissolution Apparatus do not work
  - Apparatus 1: Gelatin and oil mix clogs the basket mesh
  - Apparatus 2: Capsules usually float
    - If rupture, low density content migrate to the surface with insufficient mixing power

- Need innovative testing design
Flow-through cell designed for lipid-filled soft shell capsules

July-Aug. 2009 – PF 35(4), USP 33 2S
Test 2—
If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 2.

Medium: 45 mM citrate buffer, pH 6.0; 250 mL.
Apparatus 3: 30 dpm.
Screen (Top & Bottom): 56-mesh.
Time: 1 hour.
## Dissolution Results:

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<td>111</td>
<td>104</td>
<td>109</td>
</tr>
</tbody>
</table>
Dissolution Profiles:

- Folic Acid
- Pyridoxine HCl
LIMITATIONS

- The method works for some formulations.
- The method may need to be modified for evaluation of other soft gel capsules containing water- and oil-soluble vitamins with minerals.
  - use of surfactants
  - use of enzymes
  - mesh change
Formulations 2-4: “All in one” - soft gel capsules containing water- and oil soluble vitamins with minerals
Dissolution of Soft Shell Capsules – Apparatus 3

Formulations 5-6 - tablet products

Folic Acid Release

Vitamin B6 Release

Formulation 1
Formulation 5
Formulation 6
Reference Standards Use
Saw Palmetto: An ideal case

Print of window 38: Current Chromatogram(s)

Current Chromatogram(s)
FIDTA of SWPALM20D

2.719 - Methyl Caproate
3.532 - Methyl Caprylate
5.269 - Methyl Caprate
6.599 - Methyl Laurate
6.607 - ISTD (Nonadecane)
7.666 - Methyl Myristate
9.600 - Methyl Palmitate
9.311 - Methyl Palmitoleate
11.380 - Methyl Stearate
11.882 - Methyl Oleate
12.561 - Methyl Linoleate
13.792 - Methyl Linolenate

Instrument 1 4/29/96 12:17:59 PM Doug Johnston
Alternatives to Expensive or Unavailable Marker Compounds

- Standardized and Quantified Extracts
- Surrogate compounds

Problem: If the exact marker is not used, location of right compound in the chromatogram is a challenge
USP Approach to the Problem: three components linked to each other

- USP Monograph with a System Suitability Requirement
- Complex Multi-component Reference Standard Materials (Extracts)
- Reference Chromatogram
USP characterizes reference extracts and assigns identity to relevant peaks.

Each lot of reference extract is accompanied of one reference chromatogram.

System suitability requirements are met if a chromatogram similar to that provided with each lot of reference standard is obtained by the analyst.

The analyst now is able to identify the peaks by comparison with the reference chromatogram.
What is a similar chromatogram?

- Similar: permits differences in retention times but allows the identification of the relevant peaks by recognizing their relative abundance and elution order.

- System suitability allows modification of chromatographic system parameters (flow, column dimensions, proportions of solvents, gradient steps) in order to achieve appropriate separation.
Asian Ginseng Extract, Laboratory C
Asian Ginseng two tablets,
Elemental Contaminants

Traditional Pharmacopeial methods based on sulfide precipitation are:
- Outdated
- Not Specific
- Issues with Recoveries

FDA would accept limits set by other standard setting organizations.
Specifications for Elemental Contaminants

Focus on Big-4 heavy metals –

Cd, As, Pb, and Hg (including CH₃-Hg)
Approach to Dietary Supplement Limits

- environment
- food
- water
- drugs and DS

total exposure
Limits in GC <2232>

- As (inorganic): 15 µg/day
- Cd: 5 µg/day
- Pb: 10 µg/day
- Hg (total): 15 µg/day
- Methylmercury: 2 µg/day (no limit in GC <232>)

Speciation
- As
  - Total As: ≤ 15 µg/day → No need for speciation
- Hg
  - Total Hg: ≤ 2 µg/day → No need for speciation
  - 2 < total Hg ≤ 15 µg/day → Speciation for CH₃-Hg
Need Speciation of Arsenic & Mercury

- Arsenic
  - Highly toxic in inorganic form
  - Nontoxic in some organic forms

• Mercury
  - Highly toxic organic form
  - Less toxic in some inorganic forms
Botanicals—General Chapter <563>

- TLC/HPTLC
- HPLC chromatogram description
- Botanical Characteristics
  - Macroscopic
  - Microscopic

Three frequently cited examples: Ginseng, Ginkgo and Bilberry
Macroscopic Descriptions

Asian Ginseng  American Ginseng  Notoginseng
Microscopic Descriptions

Fig. 2b Microscopic features of transverse section of *Panax ginseng* C. A. Mey. root
A. Sketch  B. Illustration of transverse section  C. Magnification showing resin canal  D. Magnification showing parenchymatous cells with clusters of calcium oxalate

Fig. 2a Microscopic features of transverse section of *Panax quinquefolius* L. root
A. Sketch  B. Illustration of transverse section  C. Magnification showing resin canal and parenchymatous cells with a cluster of calcium oxalate
  a. Features under a light microscope  b. Features under a polarizing microscope
Peak ratios in fingerprint chromatograms

Asian Ginseng

Notoginseng

American Ginseng

Peak ratios in fingerprint chromatograms
Ginkgo TLC/HPLTC
HPLC Complementary Tests

Ginkgo (terpenelactones chromatogram)

Ginkgo (flavonols chromatogram)
USP Bilberry Monograph, TLC test
USP Bilberry monograph, HPLC test

Content of anthocyanosides and anthocyanidins

Fig. 4 Typical chromatogram of USP Powdered Bilberry Extract RS
Thank You and Questions
Thank You