Medium-Chain Triglycerides

Glycerides, mixed decanoyl and octanoyl; Caprylic and capric triglycerides.

**DEFINITION**
Medium-Chain Triglycerides consist of a mixture of triglycerides of saturated fatty acids, mainly of caprylic acid (C₈H₁₆O₃) and capric acid (C₁₀H₂₀O₃). The fatty acids are derived from the oil extracted from the hard, dried fraction of the endosperm of *Cocos nucifera* L. or from the dried endosperm of *Elaeis guineensis* Jacq. They contain NLT 95% of saturated fatty acids with 8 and 10 carbon atoms.

**IDENTIFICATION**
- **A.** Meet the requirements in Specific Tests for Fats and Fixed Oils (401), Procedures, Saponification Value
- **B.** Meet the requirements in Specific Tests for Fats and Fixed Oils (401), Procedures, Fatty Acid Composition

**IMPURITIES**

**Delete the following:**

**• LIMIT OF COPPER**
[Note—Use this test for Medium-Chain Triglycerides intended for use in parenteral nutrition.]

Sample stock solution and Sample solution: Proceed as directed in the test for Limit of Chromium.

Copper standard stock solution: 0.393 mg/mL of cupric sulfate in water

Copper standard solution: Immediately before use, prepare 0.393 µg/mL of cupric sulfate in water, from the Copper standard stock solution. This solution contains the equivalent of 0.1 µg/mL of copper.

Standard solutions: Into each of three 10-mL volumetric flasks, transfer 4.0 mL of Sample stock solution. Add 1.0, 2.0, and 4.0 mL, respectively, of Copper standard solution, and dilute with disisobutyl ketone to volume. These solutions contain 0.01, 0.02, and 0.04 µg/mL of copper.

**Instrumental conditions**
(See Atomic Absorption Spectroscopy (852).)
Mode: Atomic absorption spectrophotometer equipped with a graphite furnace
Analytical wavelength: 324.7 nm
Lamp: Copper hollow-cathode
Carrier gas: Argon

**Analysis**
Samples: Standard solutions and the Sample solution
Record the average of the steady readings for each of the Standard solutions and the Sample solution in triplicate. Plot the absorbances of the Standard solutions and the Sample solution versus the concentration of added copper. Draw the straight line best fitting the points, and extrapolate the line until it meets the concentration axis. The distance between this point and the intersection of the axes represents the concentration of copper in the Sample solution.

Acceptance criteria: NMT 0.1 µg/g [IRA 1-Mar-2019]

**Delete the following:**

**• LIMIT OF LEAD**
[Note—Use this test for Medium-Chain Triglycerides intended for use in parenteral nutrition.]

Sample stock solution and Sample solution: Proceed as directed in the test for Limit of Chromium.

Lead standard stock solution: Dissolve 160 mg of lead nitrate in 100 mL of water that contains 1 mL of lead-free nitric acid, and dilute with water to 1000 mL. Pipet 10 mL of this solution into a 100-mL volumetric flask, and dilute with water to volume.

Lead standard solution: Immediately before use, prepare 0.16 µg/mL of lead nitrate from the Lead standard stock solution. This solution contains the equivalent of 0.1 µg/mL of lead.

Standard solutions: Into each of three 10-mL volumetric flasks, transfer 4.0 mL of Sample stock solution. Add 1.0, 2.0, and 4.0 mL, respectively, of Lead standard solution, and dilute with disisobutyl ketone to volume. These solutions contain 0.01, 0.02, and 0.04 µg/mL of lead.

**Instrumental conditions**
(See Atomic Absorption Spectroscopy (852).)
Mode: Atomic absorption spectrophotometer equipped with a graphite furnace coated inside with palladium carbide
[Note—Calcination is carried out in the presence of oxygen at a temperature below 800°.]

Analytical wavelength: 283.3 nm

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Delete the following:

**LIMIT OF NICKEL**

[Note—Use this test for Medium-Chain Triglycerides intended for use in parenteral nutrition.]

**Sample stock solution** and **Sample solution**: Proceed as directed in the test for Limit of Chromium.

**Nickel standard solution**: Immediately before use, dilute 10 mL of nickel standard solution TS with water to 1000 mL. This solution contains the equivalent of 0.1 µg/g of nickel.

**Standard solutions**: Into each of three 10-mL volumetric flasks, transfer 4.0 mL of **Sample stock solution**. Add 1.0, 2.0, and 4.0 mL, respectively, of Tin standard solution, and dilute with diisobutyl ketone to volume. These solutions contain 0.01, 0.02, and 0.04 µg/mL of tin.

**Instrumental conditions**

(See Atomic Absorption Spectroscopy (852).)

**Mode**: Atomic absorption spectrophotometer equipped with a graphite furnace coated inside with palladium carbide.

**Analytical wavelength**: 286.3 nm

**Lamp**: Tin hollow-cathode

**Carrier gas**: Argon

**Analysis**

**Samples**: **Standard solutions and the Sample solution**

Record the average of the steady readings for each of the **Standard solutions and the Sample solution** in triplicate.

Plot the absorbances of the **Standard solutions and the Sample solution** versus the concentration of added lead.

Draw the straight line best fitting the points, and extrapolate the line until it meets the concentration axis. The distance between this point and the intersection of the axes represents the concentration of lead in the **Sample solution**.

**Acceptance criteria**: NMT 0.1 µg/g (IRA 1-Mar-2019)

Delete the following:

**LIMIT OF TIN**

[Note—Use this test for Medium-Chain Triglycerides intended for use in parenteral nutrition.]

**Sample stock solution** and **Sample solution**: Proceed as directed in the test for Limit of Chromium.

**Tin standard stock solution**: Immediately before use, dilute 10 mL of Tin standard stock solution with dilute hydrochloric acid (2.5 in 100) to 1000 mL, and then dilute 10 mL of the solution with water to 500 mL. This solution contains the equivalent of 0.1 µg/g of tin.

**Standard solutions**: Into each of three 10-mL volumetric flasks, transfer 4.0 mL of **Sample stock solution**. Add 1.0, 2.0, and 4.0 mL, respectively, of Tin standard solution, and dilute with diisobutyl ketone to volume. These solutions contain 0.01, 0.02, and 0.04 µg/mL of tin.

**Instrumental conditions**

(See Atomic Absorption Spectroscopy (852).)

**Mode**: Atomic absorption spectrophotometer equipped with a graphite furnace coated inside with palladium carbide.

**Analytical wavelength**: 286.3 nm

**Lamp**: Tin hollow-cathode

**Carrier gas**: Argon

**Analysis**

**Samples**: **Standard solutions and the Sample solution**

Record the average of the steady readings for each of the **Standard solutions and the Sample solution** in triplicate.

Plot the absorbances of the **Standard solutions and the Sample solution** versus the concentration of added tin.

Draw the straight line best fitting the points, and extrapolate the line until it meets the concentration axis. The distance between this point and the intersection of the axes represents the concentration of tin in the **Sample solution**.

**Acceptance criteria**: NMT 0.1 µg/g (IRA 1-Mar-2019)

Add the following:

**LIMIT OF CHROMIUM, COPPER, LEAD, AND NICKEL**

[Note—Use this test for Medium-Chain Triglycerides intended for use in parenteral nutrition.]

**Internal standard solution**: [Note—Prepare this solution fresh every 6 months.] Transfer 2.0 mL of a solution containing 1000 mg/L of yttrium [Note—Yttrium ICP standard solutions are commercially available.1] and 2.0 mL of a solution containing 1000 mg/L of lutetium [Note—Lutetium ICP standard solutions are commercially available.2] to a 1000-mL volumetric flask, add 10 mL of 65% ultratrace nitric acid, dilute with water to volume, and mix.

**Blank standard**: Transfer 1.0 mL of the **Internal standard solution** to a 100-mL volumetric flask, add 10.0 mL of 65% ultratrace nitric acid, dilute with water to volume, and mix.

**Standard stock solution**: Transfer 1.0 mL each of the solutions containing 1000 mg/L of chromium, copper, lead, and nickel [Note—Single-element ICP standard solutions are commercially available.3] to a 100-mL volumetric flask, add 10.0 mL of 65% ultratrace nitric acid, dilute with water to volume, and mix.

[Note—Prepare this solution fresh monthly.] Transfer 1.0 mL of this solution to a 100-mL volumetric flask, add 10 mL of 65% ultratrace nitric acid, dilute with water to volume, and mix. The concentration of each element in this solution is 100 µg/L. [Note—Prepare this solution fresh weekly.]

**Standard solutions**: [Note—Prepare these solutions fresh each time.] Into two separate 100-mL volumetric flasks, transfer 1.0 mL and 5.0 mL of the **Standard stock solution**, and add 1.0 mL of the **Internal standard solution** and 10.0 mL of 65% ultratrace nitric acid, dilute with water to volume, and mix well. The concentration of each element in these solutions is 1 µg/L and 5 µg/L, respectively.

1 A suitable yttrium ICP standard is available from LGC (www.lgcsstandards.com) or Millipore Sigma (www.sigmaaldrich.com).
2 A suitable lutetium ICP standard is available from LGC (www.lgcsstandards.com) or Millipore Sigma (www.sigmaaldrich.com).
3 Suitable single-element ICP standards are available from LGC (www.lgcsstandards.com) or Millipore Sigma (www.sigmaaldrich.com).

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Sample solution: Transfer 3.5 g of Medium-Chain Triglycerides into a suitable quartz flask. Add 5 mL of concentrated sulfuric acid and heat slowly on a hot-plate in a fume hood. At the boiling heat, carefully add 5 mL of 30% hydrogen peroxide in 1-mL increments. Continue heating until the solution is clear and colorless. Otherwise, add another 3 mL concentrated sulfuric acid and continue to add more 30% hydrogen peroxide. After cooling, cautiously add about 5 mL of water dropwise. Quantitatively transfer the flask’s contents into a clean, dry, 20-mL volumetric flask, dilute with water to volume, and mix. Transfer 1.0 mL of digestion solution to a 20-mL volumetric flask, add 0.2 mL of the Internal standard solution and 2.0 mL of 65% ultratrace nitric acid, dilute with water to volume, and mix. Retain the remaining digestion solution for use in the test for Limit of Tin.

Blank solution: Prepare the blank digestion solution following the preparation procedure for the Sample solution, but without using Medium-Chain Triglycerides.

Instrumental conditions
(See Plasma Spectrochemistry (730)).
Mode: ICP–MS
Spectrometer: Quadrupole mass spectrometer
Detector: Ion detector maintained under vacuum

System suitability
Samples: Blank standard and Standard solutions
Suitability requirements: Instrument performance must be verified to conform to the manufacturer’s specifications for resolution and sensitivity. Before analyzing the Sample solutions, the instrument must pass a suitable performance check. The instrument should read all isotopes for the following elements shown in Table 1 for the yttrium internal standard (89 amu) and the lutetium internal standard (175 amu), and should report the total element contents using the isotopes. Generate the calibration curve using the Blank standard and Standard solutions for each element. The linear regression coefficient is NLT 0.99.

Analysis
Samples: Blank solution and Sample solution
Determine the concentration of each element in the Blank solution and in the Sample solution using the calibration curve.

Sample solution

Acceptance criteria: See Table 2,

<table>
<thead>
<tr>
<th>Element</th>
<th>Acceptance Criteria, µg/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>0.1</td>
</tr>
<tr>
<td>Lead</td>
<td>0.1</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.1 (IRA 1-Mar-2019)</td>
</tr>
</tbody>
</table>

Add the following:

**Limit of Tin**

[Note—Use this test for Medium-Chain Triglycerides intended for use in parenteral nutrition.]

Internal standard solution, Sample solution, Blank solution, Instrumental conditions, System suitability, and Analysis: Proceed as directed in the test for Limit of Chromium, Copper, Lead, and Nickel

Blank standard: Transfer 1.0 mL of the Internal standard solution to a 100-mL volumetric flask, add 10.0 mL of 30% hydrochloric acid, dilute with water to volume, and mix.

Standard stock solution: Transfer 1.0 mL of a solution containing 1000 mg/L of tin [Note—Single-element ICP standard solutions are commercially available.] to a 100-mL volumetric flask, add 25.0 mL of 30% hydrochloric acid, dilute with water to volume, and mix.

[Note—Prepare this solution fresh monthly.] Transfer 1.0 mL of this solution to a 100-mL volumetric flask, add 25.0 mL of 30% hydrochloric acid, dilute with water to volume, and mix. The concentration of tin in this solution is 100 µg/L. [Note—Prepare this solution fresh each time.]

Standard solutions: [Note—Prepare these solutions fresh each time.] Into two separate 100-mL volumetric flasks, transfer 1.0 mL and 5.0 mL of the Standard stock solution, add 1.0 mL of the Internal standard solution and 25.0 mL of 30% hydrochloric acid, dilute with water to volume, and mix well. The concentration of tin in these solutions is 1 µg/L and 5 µg/L, respectively.

Acceptance criteria: NMT 0.1 µg/g

**Alkaline Impurities**

Sample solution: Dissolve 2.0 g of Medium-Chain Triglycerides in a mixture of alcohol and ethyl ether (1.5: 3.0).

Analysis: Add 0.05 mL of bromophenol blue TS to the Sample solution, and titrate with 0.01 N hydrochloric acid to a yellow endpoint.

Acceptance criteria: NMT 0.15 mL of 0.01 N hydrochloric acid is required.
4 Triglycerides

SPECIFIC TESTS

- **Fats and Fixed Oils** (401), Procedures, Unsaponifiable Matter
  Sample: 5.0 g
  Acceptance criteria: NMT 0.5%

- **Specific Gravity** (841): 0.93–0.96 at 20°

- **Water Determination** (921), Method I: NMT 0.2%

- **Appearance**
  Diluent: Hydrochloric acid and water (2.75%: 97.25%)
  Sample: 10 mL
  Standard solution: Prepare immediately before use by mixing 2.4 mL of ferric chloride CS and 0.6 mL of cobaltous chloride CS with Diluent to make 10.0 mL, and diluting 5.0 mL of the solution with Diluent to make 10.0 mL.
  Analysis: Compare the Sample and the Standard solution by viewing them downward in matched color-comparison tubes against a white surface (see Color and Achromicity (631)).
  Acceptance criteria: The Sample is clear and not more intensely colored than the Standard solution.

- **Fats and Fixed Oils** (401), Procedures, Acid Value: NMT 0.2

- **Fats and Fixed Oils** (401), Procedures, Fatty Acid Composition: The fatty acid fraction of Medium-Chain Triglycerides exhibits the following composition as seen in Table 3. Disregard any peak with an area less than 0.05% of the total area.

<table>
<thead>
<tr>
<th>Carbon-Chain Length</th>
<th>Number of Double Bonds</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0</td>
<td>≤2.0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>50.0–80.0</td>
</tr>
</tbody>
</table>

Table 3 (continued)

<table>
<thead>
<tr>
<th>Carbon-Chain Length</th>
<th>Number of Double Bonds</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
<td>20.0–50.0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>≤3.0</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>≤1.0</td>
</tr>
</tbody>
</table>

- **Fats and Fixed Oils** (401), Procedures, Hydroxyl Value: NMT 10
- **Fats and Fixed Oils** (401), Procedures, Iodine Value: NMT 1.0
- **Fats and Fixed Oils** (401), Procedures, Peroxide Value: NMT 1.0
- **Fats and Fixed Oils** (401), Procedures, Saponification Value
  Sample: 1.0 g
  Acceptance criteria: 310–360
- **Viscosity—Capillary Methods** (911)
  Analysis: Determine at 20 ± 0.1° with a capillary viscometer.
  Acceptance criteria: 25–33 centipoises
- **Refractive Index** (831): 1.440–1.452 at 20°
- **Articles of Botanical Origin** (561), Methods of Analysis, Total Ash
  Sample: 2.0 g
  Acceptance criteria: NMT 0.1%

ADDITIONAL REQUIREMENTS

- **Packaging and Storage**: Preserve in tight containers, protected from light. Store at temperatures not exceeding 25°.
- **Labeling**: Where it is intended for use in parenteral nutrition, it is so labeled.