Standard Method Performance Requirements (SMPRs) for Determination of Vitamins K$_1$ and K$_2$ in Dietary Supplements and Dietary Ingredients

Intended Use: Reference Method for cGMP Compliance

1 Applicability

Individually separate and quantify cis and trans forms of vitamin K$_1$ (phylloquinone); all-trans forms of both MK-4 and MK-7 (vitamin K$_2$); and determine area % for total cis forms of vitamin K$_2$ in dietary ingredients and dietary supplements as listed in Table 1.

2 Analytical Technique

Any analytical technique that meets the following method performance requirements is acceptable.

3 Definitions

Dietary ingredients.—A vitamin; a mineral; an herb or other botanical; an amino acid; a dietary substance for use by man to supplement the diet by increasing total dietary intake; or a concentrate, metabolite, constituent, extract, or combination of any of the above dietary ingredients. [United States Federal Food Drug and Cosmetic Act §201(ff) [U.S.C. 321 (ff)]]

Dietary supplements.—A product intended for ingestion that contains a “dietary ingredient” intended to add further nutritional value to (supplement) the diet. Dietary supplements may be found in many forms such as tablets, capsules, softgels, gelcaps, liquids, or powders.

Limit of quantitation (LOQ).—The minimum concentration or mass of analyte in a given matrix that can be reported as a quantitative result.

Repeatability.—Variation arising when all efforts are made to keep conditions constant by using the same instrument and operator and repeating during a short time period. Expressed as the repeatability standard deviation (SD$_r$); or % repeatability relative standard deviation (%RSD$_r$).

Reproducibility.—The standard deviation or relative standard deviation calculated from among-laboratory data. Expressed as the reproducibility standard deviation (SD$_R$); or % reproducibility relative standard deviation (%RSD$_R$).

Recovery.—The fraction or percentage of spiked analyte that is recovered when the test sample is analyzed using the entire method.

Vitamin K$_1$.—Phylloquinone. IUPAC name: 2-methyl-3-[(2E)-3,7,11,15-tetramethyl hexadec-2-en-1-yl]naphthoquinone (CAS No. 084-80-0). See Figure 1.

Vitamin K$_2$.—Menaquinone with several subtypes designated as MK-n. “MK” identifies the basic quinone ring structure and “n” designating the number of attached isoprenoid units. See Figure 1.

MK-4.—IUPAC name: 2-methyl-[3-(2E,6E,10E)-3,7,11,15-tetramethyl-2,6,10,14-hexadecatetraen-1-y1]-1,4-naphthalenedione (CAS No. 863-61-6).

MK-7.—IUPAC name: 2-[(2E,6E,10E,14E,18E,22E)-3,7,11,15,19,23,27-heptamethyllocta-2,6,10,14,18,22,26-heptaenyl]-3-methylnaphthalene-1,4-dione (CAS No. 2124-57-4).

4 Method Performance Requirements

See Tables 2 and 3.

5 System Suitability Tests and/or Analytical Quality Control

Suitable methods will include blank check samples, and check standards at the lowest point and midrange point of the analytical range. A control sample must be included.

6 Reference Material(s)

NIST SRM 3280
NIST SRM 1849a
NIST SRM 3232
MK-4: Sigma-Aldrich V031 Cerilliant
MK-7: USP 1381119
K1: USP 1358006
K1: NIST SRM 3280 Multivitamin Tablet


7 Validation Guidance

All target analytes (vitamin K$_1$, MK-4, and MK-7) and all claimed matrixes listed in Table 1 shall be evaluated. One analyte
per claimed matrix is acceptable provided all three analytes are represented in the complete evaluation.


8 Maximum Time-to-Determination

No maximum time.

Approved by the AOAC Stakeholder Panel on Dietary Supplements (SPDS) on March 17, 2017. Final Version Date: March 17, 2017.

### Table 2. Analytical range and LOQ based on matrix

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dietary supplements</th>
<th>Dietary ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical range, ppm</td>
<td>1–3000</td>
<td>1000–1M</td>
</tr>
<tr>
<td>LOQ, ppm</td>
<td>0.5</td>
<td>200</td>
</tr>
</tbody>
</table>

* Measured as individual forms of vitamins K\(_1\) and K\(_2\) and their isomers.

### Table 3. Method performance requirements as a function of range

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range, ppm*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1–100</td>
</tr>
<tr>
<td>Recovery, %</td>
<td>80–110</td>
</tr>
<tr>
<td>RSD(_r), %</td>
<td>≤11</td>
</tr>
<tr>
<td>RSD(_w), %</td>
<td>≤15</td>
</tr>
</tbody>
</table>

* Measured as individual forms of vitamins K\(_1\) and K\(_2\) and their isomers.