National Institute of Standards and Technology
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Standard Reference Material® 2386
Avocado Powder
CERTIFICATE OF ANALYSIS

Purpose: This Standard Reference Material (SRM) is intended for the evaluation of methods for the determination of elements, vitamins, amino acids, proximates, and fatty acids in a freeze-dried avocado powder and similar matrices and can be used for quality assurance, such as when assigning values to in-house control materials.

Description: A unit of SRM 2386 consists of five packets, each containing approximately 10 g of freeze-dried avocado powder.

Certified Mass Fraction Values: A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias and variability have been taken into account [1].

Certified mass fraction values for elements in SRM 2386, reported on a dry-mass basis, are provided in Table 1. Certified mass fraction values for selected water-soluble vitamins and related analytes, reported on a dry-mass basis, are provided in Table 2. Values are expressed as $x \pm U_{95\%}(x)$, where x is the certified value and $U_{95\%}(x)$ is the expanded uncertainty of the certified value. The true value of the analyte is believed to lie within the interval $x \pm U_{95\%}(x)$ with 95 % confidence. To propagate this uncertainty, treat the certified value as a normally distributed random variable with mean x and standard deviation $U_{95\%}(x)/2$ [2–4]. The results in Tables 1 and 2 are expressed as mass fractions in units of milligrams analyte per kilogram sample (mg/kg). Metrological traceability is to the International System of Units (SI) unit for mass [2] through the purity evaluations and gravimetric procedures used in the preparation of calibration solutions.

Table 1. Certified Mass Fraction Values (Dry-Mass Basis) for Elements in SRM 2386

Element	Mass Fraction (mg/kg)		
Calcium (Ca)	777	±	62
Cadmium (Cd)	0.1420	±	0.0099
Copper (Cu)	16.22	±	0.60
Iron (Fe)	33.6	±	1.4
Magnesium (Mg)	2000	±	540
Manganese (Mn)	10.72	±	0.70
Phosphorus (P)	3590	±	210
Potassium (K)	36400	±	5000
Sodium (Na)	870	±	140
Zinc (Zn)	36.6	±	2.6

Non-Certified Values: Non-certified values for SRM 2386 are provided in Appendix A.

Period of Validity: The certified values delivered by **SRM 2386** are valid within the measurement uncertainty specified until **01 July 2031**. The certified values are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified.

Maintenance of Certified Values: NIST will monitor this SRM to the end of the period of validity. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet or register online) will facilitate notification.

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Table 2. Certified Mass Fraction Values (Dry-Mass Basis) for Water-Soluble Vitamins and Related Analytes in SRM 2386

Analyte	Mass Fraction (mg/kg)
Thiamine	1.82 ± 0.17
Riboflavin	7.7 ± 1.4
Niacin	107 ± 31
Niacinamide	6.56 ± 0.87
Total Vitamin B_3	101 ± 24
Pantothenic Acid	67 ± 11
Pyridoxal	1.81 ± 0.68
Pyridoxine	3.60 ± 0.41
Total Vitamin B_6 as Pyridoxine	5.4 ± 2.1
Ascorbic Acid	186 ± 11
Choline	1470 ± 140
Carnitine	2.15 ± 0.46

Analysis: Measurements used to value assign SRM 2386 values were performed at NIST using a variety of analytical techniques and by participants of interlaboratory comparison studies sponsored by the Grocery Manufacturers Association's Food Industry Analytical Chemists (GMA FIAC) Share Group using their routine methods [5].

Safety: SRM 2386 IS INTENDED FOR RESEARCH USE; NOT FOR HUMAN CONSUMPTION.

Storage: The SRM 2386 packets should be stored unopened, in the dark, at controlled room temperature (20 °C to 25 °C) until needed. The certified mass fraction values do not apply to contents of previously opened and stored packets as the stability of the measurands in opened packets has not been investigated.

Use: Prior to removal of a test portion for analysis, the contents of a packet of material should be mixed thoroughly. To relate analytical determinations to the certified values in this Certificate of Analysis, test portions for analysis should be equal to or greater than 0.5 g for elements and 1 g for water-soluble vitamins and related analytes (2 g for vitamin C). Test portions should be analyzed as-received and results converted to a dry-mass basis using the procedure described below (see "Determination of Moisture").

Determination of Moisture: Moisture content of SRM 2386 was determined using results from three NIST techniques and results from the GMA FIAC [5]. The method estimates were combined to estimate a dry-mass proportion of (0.9516 ± 0.0178) gram dry-mass per gram as-received mass; the uncertainty shown on this value is an expanded uncertainty to represent a 95 % level of confidence. The moisture correction is achieved by multiplying the as-received measurements by a conversion factor equal to the inverse of the dry-mass proportion. A relative uncertainty component for the conversion factor obtained from the moisture measurements (0.9 %) is incorporated in the uncertainties of the estimated analyte values (except ash), reported on a dry-mass basis, that are provided in this certificate.

Source: SRM 2386 was prepared from packets of freeze-dried avocado powder that were obtained from a commercial source.

Additional Information: The development of SRM 2386 was motivated by requests from the food industry and federal regulators for food-matrix reference materials to support nutrition labelling. Full details on the production and evaluation of SRM 2386 are provided free of charge in [5].

REFERENCES

[1] Beauchamp, C.R.; Camara, J.E.; Carney, J.; Choquette, S.J.; Cole, K.D.; DeRose, P.C.; Duewer, D.L.; Epstein, M.S.; Kline, M.C.; Lippa, K.A.; Lucon, E.; Molloy, J.; Nelson, M.A.; Phinney, K.W.; Polakoski, M.; Possolo, A.; Sander, L.C.; Schiel, J.E.; Sharpless, K.E.; Toman, B.; Winchester, M.R.; Windover, D.; *Metrological Tools for the Reference Materials and Reference Instruments of the NIST Material Measurement Laboratory*; NIST Special Publication (NIST SP) 260-136, 2021 edition; U.S. Government Printing Office: Washington, DC (2021); available at https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.260-136-2021.pdf (accessed Nov 2021).

[2] Thompson, A.; Taylor, B.N.; *Guide for the Use of the International System of Units (SI)*; NIST Special Publication 811; U.S. Government Printing Office: Washington, DC (2008); available at https://www.nist.gov/pml/special-publication-811 (accessed Nov 2021).

[3] JCGM 100:2008; *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (GUM 1995 with Minor Corrections); Joint Committee for Guides in Metrology (JCGM) (2008); available at https://www.bipm.org/en/publications/guides (accessed Nov 2021); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297; U.S. Government Printing Office: Washington, DC (1994); available at https://www.nist.gov/pml/nist-technical-note-1297 (accessed Nov 2021).

[4] JCGM 101:2008; *Evaluation of Measurement Data — Supplement 1 to the "Guide to the Expression of Uncertainty in Measurement" — Propagation of Distributions Using a Monte Carlo Method*; Joint Committee for Guides in Metrology (JCGM) (2008); available at https://www.bipm.org/en/publications/guides (accessed Nov 2021).

[5] Phillips, M.M.; Wood, L.J.; Browning, J.F.; Caceres, G.C.; Hahm, G.E.; Hanaee, M.; Lee, A.; Murphy, K.E.; Oflaz, R.; Paul, R.; Place, B.J.; Thomas, J.B.; Yen, J.; *Certification of Standard Reference Material® 2386 Avocado Powder*; NIST Special Publication (NIST SP) 260-213 (2021); available at https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.260-213.pdf (accessed Nov 2021).

If you use this SRM in published work, please reference:

Phillips MM, Wood LJ, Browning JF, Caceres GC, Hahm GE, Hanaee M, Lee A, Murphy KE, Oflaz R, Paul R, Place BJ, Thomas JB, Yen J (2021) Certification of Standard Reference Material® 2386 Avocado Powder. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) 260-213. https://doi.org/10.6028/NIST.SP.260-213

Certain commercial equipment, instruments or materials may be identified in this Certificate of Analysis to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Users of this SRM should ensure that the Certificate of Analysis in their possession is current. This can be accomplished by contacting the Office of Reference Materials 100 Bureau Drive, Stop 2300, Gaithersburg, MD 20899-2300; telephone (301) 975-2200; e-mail srminfo@nist.gov; or the Internet at https://www.nist.gov/srm.

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APPENDIX A

Non-Certified Values: Non-certified values are suitable for use in method development, method harmonization, and process control but do not meet the NIST criteria for certification [1]. They are the best estimates of the true values based on available data. The values are provided with an uncertainty that may reflect only measurement reproducibility, may not include all sources of uncertainty, and/or may reflect a lack of sufficient statistical agreement among multiple analytical methods.

Non-certified mass fraction values for elements, fatty acids, and proximates in SRM 2386, reported on a dry-mass basis, are provided in Tables A1 through A3. Values are expressed as $x \pm 2u(x)$, where x is the non-certified value and $u(x)$ is the standard uncertainty of the non-certified value. To propagate this uncertainty, the non-certified value should be treated as a normally distributed random variable with mean x and standard deviation $u(x)$ [2–4]. These values are metrologically traceable to results from NIST measurement procedures and/or reported by participants of interlaboratory comparison studies sponsored by the GMA FIAC Share Group using their routine methods [5].

Table A1. Non-Certified Mass Fraction Values (Dry-Mass Basis) for Elements in SRM 2386

Element	Mass Fraction (mg/kg)	n[(a)]
Boron (B)	172 ± 14	1
Molybdenum (Mo)	0.09 ± 0.02	3
Selenium (Se)	0.05 ± 0.03	5

[(a)] Number of contributors providing technically valid results

Table A2. Non-Certified Mass Fraction Values (Dry-Mass Basis) for Fatty Acids in SRM 2386

	Common Name	Mass Fraction (g/100 g)	n[(a)]
Tetradecanoic Acid (C14:0)	Myristic Acid	0.014 ± 0.004	18
Hexadecanoic Acid (C16:0)	Palmitic Acid	3.28 ± 0.17	20
(Z)-9-Hexadecenoic Acid (C16:1 n7)	Palmitoleic Acid	1.186 ± 0.036	19
Octadecanoic Acid (C18:0)	Stearic Acid	0.105 ± 0.006	20
(Z)-9-Octadecenoic Acid (C18:1 n9)	Oleic Acid	12.95 ± 0.53	14
(Z)-11-Octadecenoic Acid (C18:1 n7)	Vaccenic Acid	1.24 ± 0.11	14
Total *cis*-C18:1		16.0 ± 2.3	19
(Z,Z)-9,12-Octadecadienoic Acid (C18:2 n6)	Linoleic Acid	2.219 ± 0.070	19
Total *cis*-C18:2		2.219 ± 0.061	13
(Z,Z,Z)-9,12,15-Octadecatrienoic Acid (C18:3 n3)	α-Linolenic Acid	0.214 ± 0.022	11
(Z,Z,Z)-6,9,12-Octadecatrienoic Acid (C18:3 n6)	γ-Linolenic Acid	0.010 ± 0.005	19
Eicosanoic Acid (C20:0)	Arachidic Acid	0.017 ± 0.004	17
Total *cis*-C20:1		0.044 ± 0.004	19
Tetracosanoic Acid (C24:0)	Lignoceric Acid	0.026 ± 0.008	16
Saturated Fat		3.66 ± 0.19	19
cis-Monounsaturated Fat		17.9 ± 1.1	19
cis-Polyunsaturated Fat		2.52 ± 0.24	19
Total Trans Fat		0.043 ± 0.027	13
Total ω-3 Fatty Acids		0.218 ± 0.022	16
Total ω-6 Fatty Acids		2.26 ± 0.16	18

[(a)] Number of contributors providing technically valid results

Table A3. Non-Certified Mass Fraction Values (Dry-Mass Basis) for Proximates in SRM 2386

Analyte	Mass Fraction (g/100 g)	$n^{(a)}$
Ash	7.5 ± 1.4	14
Protein	9.96 ± 0.37	15
Carbohydrates	48.4 ± 4.4	13
Fat (sum of fatty acids as triglycerides)	31.0 ± 3.6	11
Total Dietary Fiber	21.9 ± 2.6	12
Total Sugars	2.64 ± 0.51	12

[a] Number of contributors providing technically valid results

Non-certified mass fraction values for water-soluble vitamins and related compounds, fat-soluble vitamins, calories, and amino acids in SRM 2386, reported on a dry-mass basis, are provided in Tables A4 through A7. Values are expressed as $x \pm 2u(x)$, where x is the non-certified value and $u(x)$ is the standard uncertainty of the non-certified value. To propagate this uncertainty, the non-certified value should be treated as a normally distributed random variable with mean x and standard deviation $u(x)$ [2–4]. These values are metrologically traceable to results reported by participants of interlaboratory comparison studies sponsored by the GMA FIAC Share Group using their routine methods [5].

Table A4. Non-Certified Mass Fraction Value (Dry-Mass Basis) for Total Folates in SRM 2386

Analyte	Mass Fraction (mg/kg)	$n^{(a)}$
Total Folates	2.38 ± 0.57	4

[a] Number of contributors providing technically valid results

Table A5. Non-Certified Mass Fraction Values (Dry-Mass Basis) for Fat-Soluble Vitamins in SRM 2386

Analyte	Mass Fraction (mg/kg)	$n^{(a)}$
Vitamin K	0.34 ± 0.27	3
α-Tocopherol	28 ± 13	6
γ-Tocopherol	3.9 ± 1.4	3

[a] Number of contributors providing technically valid results

Table A6. Non-Certified Value (Dry-Mass Basis) for Calories in SRM 2386

Analyte	Energy (kcal/100 g)	$n^{(a)}$
Calories	501 ± 31	13

[a] Number of contributors providing technically valid results

Table A7. Non-Certified Mass Fraction Values (Dry-Mass Basis) for Amino Acids in SRM 2386

Amino Acid	Mass Fraction (g/100 g)	$n^{(a)}$
Alanine	0.49 ± 0.04	5
Arginine	0.42 ± 0.08	5
Aspartic Acid	0.83 ± 0.08	5
Cystine	0.09 ± 0.04	3
Glutamic Acid	1.1 ± 0.1	5
Glycine	0.44 ± 0.04	5
Histidine	0.19 ± 0.04	5
Isoleucine	0.39 ± 0.10	5
Leucine	0.64 ± 0.09	5
Lysine	0.47 ± 0.14	5
Methionine	0.16 ± 0.06	4
Phenylalanine	0.37 ± 0.06	5
Proline	0.43 ± 0.07	5
Serine	0.52 ± 0.04	5
Threonine	0.40 ± 0.04	5
Tyrosine	0.29 ± 0.06	5
Valine	0.51 ± 0.14	5

[(a)] Number of contributors providing technically valid results

Period of Validity: The non-certified values are valid within the measurement uncertainty specified until **01 July 2031**. The value assignments are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified.

Maintenance of Non-Certified Values: NIST will monitor the non-certified values to the end of the period of validity. If substantive technical changes occur that affect the non-certified values during this period, NIST will update this Appendix. Before making use of any of the values delivered by this material, users should obtain the most recent version of this documentation, available free of charge through the https://www.nist.gov/srm website.

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