



# National Institute of Standards & Technology

## Certificate of Analysis

### Standard Reference Material<sup>®</sup> 3281

#### Cranberry (Fruit)

This Standard Reference Material (SRM) is intended primarily for use in validating analytical methods for the determination of organic acids in the fruit of cranberries and similar matrices. This SRM can also be used for quality assurance when assigning values to in-house control materials. A unit of SRM 3281 consists of five packets, each containing approximately 6 g of freeze-dried, powdered fruit.

The development of SRM 3281 was a collaboration between the National Institute of Standards and Technology (NIST) and the National Institutes of Health Office of Dietary Supplements (NIH-ODS).

**Certified Mass Fraction Values:** Certified mass fraction values of selected organic acids are provided in Table 1. 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 have been investigated or taken into account [1]. Values were derived from the combination of results provided by NIST using two analytical methods. The certified values in this material are the equally weighted means of the means of the individual sets of results provided by NIST. The associated uncertainties are expanded uncertainties at the 95 % level of confidence [2-4]. Values are reported on a dry-mass basis in mass fraction units [5].

**Reference Values:** Reference mass fraction values for elements and sugars are provided in Tables 2 and 3, respectively. Reference values for total antioxidant capacity are provided in Table 4. Reference values are noncertified values that are the best estimate of the true values based on available data; however, the values do not meet the NIST criteria for certification [1] and are provided with associated uncertainties that may reflect only measurement reproducibility, may not include all sources of uncertainty, or may reflect a lack of sufficient statistical agreement among multiple analytical methods.

**Expiration of Certification:** The certification of **SRM 3281** is valid, within the measurement uncertainty specified, until **30 April 2015**, provided the SRM is handled and stored in accordance with instructions given in this certificate (see "Warning and Instructions for Storage and Use"). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

**Maintenance of SRM Certification:** NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

Support for the development of SRM 3281 was provided in part by NIH-ODS. Technical consultation was provided by J.M. Betz of the NIH-ODS.

The overall direction and coordination of the technical measurements leading to the certification of this SRM were performed by L.C. Sander, K.E. Sharpless, and S.A. Wise of the NIST Analytical Chemistry Division.

Acquisition of the material was performed by K.E. Sharpless of the NIST Analytical Chemistry Division.

Statistical analysis was provided by J.H. Yen of the NIST Statistical Engineering Division.

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Certificate Issue Date: 29 February 2012  
*Certificate Revision History on Last Page*

Analytical measurements at NIST were performed by M.M. Phillips, B.J. Porter, and L.J. Wood of the NIST Analytical Chemistry Division. Results were also provided by analysts participating in two interlaboratory comparison exercise involving members of the Grocery Manufacturers Association Food Industry Analytical Chemists Committee (GMA FIACC), Washington, DC. Those participants involved in the value assignment of sugars were: Eurofins Scientific, Inc., Des Moines, IA; Hormel Foods Corporation, Austin, MN; Krueger Food Laboratories, Cambridge, MA; and The National Food Laboratory, Livermore, CA. Participants involved in the value assignment of antioxidant capacity were: Eurofins Chemical Control, Cuneo, Italy; Eurofins S&S, Hanover, MD; General Mills, Golden Valley, MN; McCormick and Company, Hunt Valley, MD; National Center of Food Safety and Technology, Summit-Argo, IL; The Hershey Company Technical Center, Hershey, PA; and Welch's, Billerica, MA. Participants that were involved in the value assignment of both sugars and antioxidant capacity were: Campbell Soup Company, Camden, NJ; and Covance, Inc., Madison, WI.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

## **WARNING AND INSTRUCTIONS FOR STORAGE AND USE**

**Warning:** For laboratory use only. Not for human consumption.

**Storage:** The material should be stored at controlled room temperature (20 °C to 25 °C), in an unopened packet, until needed. The certification does not apply to contents of previously opened and stored packets as the stability of analytes 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. For certified values to be valid, test portions of the powder equal to or greater than 0.1 g for organic acid analyses and 0.5 g for element analyses should be used. The stability of organic acids and elements in opened packets has not been investigated. Test portions should be analyzed as received and results converted to a dry-mass basis by determining moisture content (described below) on a separate test portion.

## **PREPARATION AND ANALYSIS<sup>(1)</sup>**

**Material Acquisition and Preparation:** Frozen cranberries for production of SRM 3281 were freeze-dried and ground to 420 µm (40 mesh; Van Drunen Farms, Momence, IL) and shipped to NIST where they were further ground and sieved to 180 µm (80 mesh). The material was shipped to High-Purity Standards (Charleston, SC), where it was blended, aliquotted, and heat-sealed inside nitrogen-flushed 4 mil polyethylene bags, which were then sealed inside nitrogen-flushed aluminized plastic bags along with two packets of silica gel each. Following packaging, SRM 3281 was irradiated (Neutron Products, Inc., Dickerson, MD) to an absorbed dose of 7.1 kGy to 8.9 kGy.

**Analytical Approach for Determination of Organic Acids:** Value assignment of the concentrations of the organic acids in SRM 3281 was based on the combination of measurements from two different methods: isotope dilution liquid chromatography with mass spectrometric detection (ID-LC/MS) and isotope dilution gas chromatography with mass spectrometric detection (ID-GC/MS). Duplicate test portions of approximately 0.1 g were taken from each of six packets for analysis using each of the methods, and internal standards were added. Organic acids were extracted into water, and the solutions from four such successive extractions were combined.

For analysis by ID-LC/MS, an organic acid column was held at 40 °C. An aqueous mobile phase containing 0.5 % (volume fraction) formic acid was used under isocratic conditions at a flow rate of 0.5 mL/min. The mass spectrometer was operated in negative ion mode, with atmospheric pressure electrospray ionization (AP-ESI). Each organic acid was matched with a <sup>13</sup>C- or <sup>2</sup>H-labeled internal standard, and quantitation was based on response factors calculated from the relative peak areas and concentrations [6].

For ID-GC/MS, measurements were carried out using a GC×GC/MS instrument. Portions (10 mL) of the combined water extracts were dried then mixed with N-methy-N-(trimethylsilyl)trifluoroacetamide (MSTFA) containing 1 % (volume fraction) trimethylchlorosilane (TMCS) for derivatization prior to analysis. A 5 % diphenyl/95 % dimethyl polysiloxane (mole fractions) column was used for the analysis. A second column, 50 % diphenyl/50 % dimethyl polysiloxane (mole fractions), was installed but was not utilized in two-dimensional mode. Each organic acid was matched with a <sup>13</sup>C- or <sup>2</sup>H-labeled internal standard, and quantitation was based on response factors calculated from the relative peak areas and concentrations. Although full spectra were acquired for each analyte, extracted ion chromatograms were used for quantification of each compound [6].

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<sup>(1)</sup> Certain commercial equipment, instruments or materials are identified in this certificate 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.

**Analytical Approach for Determination of Elements:** Elements were measured at NIST by using inductively coupled plasma optical emission spectrometry (ICP-OES) [7]. Two 0.5 g test portions from each of six packets of SRM 3281 were analyzed for calcium, copper, iron, magnesium, manganese, phosphorus, potassium, sodium, and zinc. Test portions were digested in sealed vessels with nitric and hydrofluoric acids using a microwave digestion system. Quantitation was based on the method of standard additions using calibration solutions prepared from the SRM 3100 Series of single-element standard solutions.

**Collaborating Laboratories' Analyses:** The GMA FIACC laboratories were asked to use their usual methods to make single measurements on test portions taken from each of two (for measurement of sugars) or three (for determination of total antioxidant capacity) packets of SRM 3281. The collaborating laboratories' data were used to assign reference values for sugars and antioxidant capacity. Three antioxidant methods were employed: oxygen radical absorbance capacity (ORAC), Folin-Ciocalteu's reagent (Folin-C), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) as the reagent.

**Determination of Moisture:** Moisture content of SRM 3281 was determined at NIST (see "Warning and Instructions for Storage and Use") by (1) freeze-drying to constant mass over 7 d; (2) drying over magnesium perchlorate in a desiccator at room temperature for 21 d; and (3) drying for 2 h in a forced-air oven at 80 °C. Unweighted results obtained using all three techniques were averaged to determine a conversion factor of  $(0.9761 \pm 0.0067)$  gram dry mass per gram as-received mass, which was used to convert data from an as-received to a dry-mass basis; the uncertainty shown on this value is an expanded uncertainty. An uncertainty component for the conversion factor (0.34 %) obtained from the moisture measurements is incorporated in the uncertainties of the certified and reference values, reported on a dry-mass basis, that are provided in this certificate.

**Homogeneity Assessment:** The homogeneity of organic acid and element contents was assessed at NIST by using the methods described above. An analysis of variance did not show inhomogeneity for the test portions analyzed (see "Warning and Instructions for Storage and Use").

**Value Assignment:** The equally weighted means from each set of NIST data available were used to calculate the assigned values for organic acids and elements. The median of laboratory means was used to calculate the reference values for sugars and total antioxidant capacity.

**Certified Mass Fraction Values for Organic Acids:** Each certified mass fraction value is an equally weighted mean of results provided by ID-LC/MS and ID-GC/MS. The uncertainty provided with each value is an expanded uncertainty about the mean to cover the measurand with approximately 95 % confidence: it expresses both the observed difference between the results from the methods and their respective uncertainties, incorporating an uncertainty component for moisture correction, consistent with the ISO Guide and its Supplement 1 [2-4]. The expanded uncertainty is calculated as  $U = ku_c$ , where  $u_c$  is intended to represent, at the level of one standard deviation, the effects of the combined components of uncertainty, and  $k$  is a coverage factor corresponding to approximately 95 % confidence for each analyte.

Table 1. Certified Mass Fraction Values for Organic Acids in SRM 3281

	Mass Fraction (mg/g)			<i>k</i>
Citric Acid	79.2	±	6.4	2.00
Malic Acid	40.6	±	2.3	2.00
Quinic Acid	47.8	±	6.8	2.00
Shikimic Acid	2.09	±	0.72	2.00

**Reference Mass Fraction Values for Elements:** Each reference mass fraction value is the mean of results provided by NIST by using ICP-OES. The uncertainty provided with each value is an expanded uncertainty about the mean to cover the measurand with approximately 95 % confidence [2]. The uncertainty incorporates within-method uncertainty and a component related to moisture correction. The expanded uncertainty is calculated as  $U = ku_c$ , where  $u_c$  is intended to represent, at the level of one standard deviation, the effects of the combined components of uncertainty, and  $k$  is a coverage factor corresponding to approximately 95 % confidence for each analyte.

Table 2. Reference Mass Fraction Values for Elements in SRM 3281

	Mass Fraction (mg/kg)			$k$
Calcium	528	±	7	2.07
Copper	3.52	±	0.09	2.18
Iron	27.7	±	0.7	2.16
Magnesium	446	±	4	2.01
Manganese	21.9	±	0.2	2.01
Phosphorus	835	±	17	2.14
Potassium	8020	±	130	2.13
Sodium	259	±	3	2.02
Zinc	6.9	±	0.2	2.17

**Reference Values for Sugars and Antioxidant Capacity:** Each reference value is the median of the mean results provided by the GMA FIACC laboratories. The uncertainty provided with each value is an expanded uncertainty about the median to cover the measurand with approximately 95 % confidence, consistent with the ISO Guide [2]. The uncertainty incorporates within-method uncertainty and a component related to moisture correction. The expanded uncertainty is calculated as  $U = ku_c$ , where  $u_c$  is intended to represent, at the level of one standard deviation, the effects of the combined components of uncertainty, and  $k$  is a coverage factor corresponding to approximately 95 % confidence for each analyte.

Table 3. Reference Mass Fraction Values for Sugars in SRM 3281

	Mass Fraction (%)			$k$
Total Sugars	26.2	±	2.1	2.55
Fructose	4.51	±	0.53	2.56
Glucose	21.6	±	1.1	2.53

Table 4. Reference Values for Total Antioxidant Capacity of SRM 3281

Method	Result		Units	$k$
ORAC	214	± 36	micromoles Trolox equivalents per gram	2.57
DPPH	254	± 136	micromoles Trolox equivalents per gram	4.30
Folin-C	20.0	± 3.2	milligrams gallic acid per gram	2.36

## REFERENCES

- [1] May, W.E.; Parris, R.M.; Beck II, C.M.; Fassett, J.D.; Greenberg, R.R.; Guenther, F.R.; Kramer, G.W.; Wise, S.A.; Gills, T.E.; Colbert, J.C.; Gettings, R.J.; MacDonald, B.R.; *Definition of Terms and Modes Used at NIST for Value-Assignment of Reference Materials for Chemical Measurements*; NIST Special Publication 260-136 (2000); available at <http://www.nist.gov/srm/publications.cfm> (accessed Feb 2012).
- [2] JCGM 100:2008; *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (ISO GUM 1995 with Minor Corrections); Joint Committee for Guides in Metrology (JCGM) (2008); available at [http://www.bipm.org/utis/common/documents/jcgm/JCGM\\_100\\_2008\\_E.pdf](http://www.bipm.org/utis/common/documents/jcgm/JCGM_100_2008_E.pdf) (accessed Feb 2012); 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 <http://www.nist.gov/pml/pubs/tn1297/index.cfm> (accessed Feb 2012).
- [3] JCGM 101:2008; *Evaluation of measurement data – Supplement 1 to the “Guide to Expression of Uncertainty in Measurement” - Propagation of distributions using a Monte Carlo method*; JCGM (2008); available at [http://www.bipm.org/utis/common/documents/jcgm/JCGM\\_101\\_2008\\_E.pdf](http://www.bipm.org/utis/common/documents/jcgm/JCGM_101_2008_E.pdf) (accessed Feb 2012).
- [4] Efron, B.; Tibshirani, R.J.; *An Introduction to the Bootstrap*; Chapman & Hall, London, UK (1993).
- [5] 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 <http://www.nist.gov/pml/pubs/sp811/index.cfm> (accessed Feb 2012).
- [6] Phillips, M.M.; Case, R.J.; Rimmer, C.A.; Sharpless, K.E.; Wise, S.A.; Sander, L.C.; *Determination of Organic Acids in Vaccinium Berry Standard Reference Materials*; *Anal. Bioanal. Chem.*, Vol. 398, pp. 425–434 (2010).
- [7] Wood, L.J.; Sharpless, K.E.; Pichon, M.; Porter, B.J.; Yen, J.H.; Ehling, S.; *Characterization of Three Berry Standard Reference Materials for Nutrients*; *J. Agric. Food Chem.*, Vol. 59, pp. 7246–7252 (2011).

<b>Certificate Revision History:</b> 29 February 2012 (Added reference values for antioxidant capacity; editorial changes); 14 September 2010 (Original certificate issue date).
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*Users of this SRM should ensure that the Certificate of Analysis in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 926-4751; e-mail [srminfo@nist.gov](mailto:srminfo@nist.gov); or via the Internet at <http://www.nist.gov/srm>.*