USDA Database for the Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods, Release 2

Prepared by

Nutrient Data Laboratory
Beltsville Human Nutrition Research Center (BHNRC)
Agricultural Research Service (ARS)
U.S. Department of Agriculture (USDA)

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U.S. Department of Agriculture
Agricultural Research Service
Beltsville Human Nutrition Research Center
Nutrient Data Laboratory
10300 Baltimore Avenue
Building 005, Room 107, BARC-West
Beltsville, Maryland 20705
Tel. 301-504-0630, FAX: 301-504-0632
E-Mail: ndlinfo@ars.usda.gov
Web site: http://www.ars.usda.gov/nutrientdata

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Release History

Release 1 – November 2007. Values reported for 277 food items.
Release 2 – February 2010. Values added for 49 food items, including maple syrup, acai, and goji berries, for a total of 326 food items. Also, the database structure was reformatted to more closely match that of the USDA National Nutrient Database for Standard Reference and other Special Interest Databases.

Suggested Citation

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Introduction

The development of various chronic and degenerative diseases, such as cancer (1), heart disease (6), and neuronal degeneration such as Alzheimer's (5) and Parkinson's disease (14) has been theorized to be caused, in part, by oxidative stress. Oxidative stress has also been implicated in the process of aging (2). Although the human body has developed a number of systems to eliminate free radicals, such as reactive oxygen species, from the body, it is not 100% efficient (25).

Diets rich in fruits, nuts, and vegetables are considered to be an excellent source of antioxidants (13). A number of minerals and vitamins have a role as dietary antioxidants in addition to their other biological functions. These include vitamin C (ascorbic acid), vitamin E and its isomers (tocopherols and tocotrienols), and selenium. Data for these are included in the USDA National Nutrient Database for Standard Reference (SR) (23). USDA has also published a number of Special Interest Databases on various antioxidants: Carotenoids (19) (now merged with SR); isoflavones (19), flavonoids (21), and proanthocyanidins (22).

Antioxidant is defined as any substance, present in small quantities that can delay or inhibit the oxidation of the oxidizable substrate (3). Primary antioxidants delay or inhibit the initiation step of oxidation, while the secondary antioxidants slow down the oxidation by removing the substrate or by quenching the free oxygen radicals. Although the definition was initially applied to the oxidation of lipids, it is now extended to the oxidation of proteins, DNA, and carbohydrates and includes all the repair systems which do not necessarily involve antioxidant activity (7).

Oxygen Radical Absorption Capacity (ORAC) assay measures the inhibition of peroxy-radical-induced oxidation by the compounds of interest. It measures the value as Trolox equivalents and includes both inhibition time and the extent of inhibition of oxidation. The assay can be used to measure the antioxidant activity of foods. The method developed by Prior et al. (17) measures both hydrophilic and lipophilic ORAC capacity for water soluble and fat soluble antioxidant compounds.

In addition to the ORAC assay, other common measures of antioxidant capacity (AC) include ferric ion reducing antioxidant power (FRAP) and trolox equivalence antioxidant capacity (TEAC) assays (3, 18). These assays are based on different underlying mechanisms using different radical or oxidant sources and therefore generate distinct values and cannot be compared directly. The ORAC assay is considered by some to be a preferable method because of its biological relevance to the *in vivo* antioxidant efficacy (4). Because antioxidant compounds with dissimilar chemical structures interact with different radical sources differently, the relationship between any two AC methods will be quite low if considered across all foods. Thus, it is not possible to develop a mathematical relationship between two methods across a wide spectrum of foods. Like the content of any food component, AC values will vary due to a wide array of reasons, such as cultivar, growing conditions, harvesting, food processing and preparation, sampling, and analytical procedures.

Procedures used to generate the database

In 2007, USDA released the first database of antioxidant activity for selected **277** foods. A portion of the data in Release 1.0 of the ORAC database was developed using samples of 59 individual fruits, nuts, and vegetables collected in 1999-2000 by USDA as part of the National Food and Nutrient Analysis Program (NFNAP) (8) in collaboration with the Produce for Better Health Foundation. These foods, as well as a few foods collected for the food composition database for American Indians and Alaskan Natives, were analyzed for ORAC by Wu et al. (24) at the Arkansas Children's Nutrition Center, ARS, USDA. Other analytical data from the literature, available at that time, was also incorporated into the ORAC database. Since then additional scientific publications containing data on the ORAC content of foods have been published, which were incorporated into this release of the database. Data were also provided by some industries. These data were aggregated with the data from release 1.0. Release 2 contains 49 new foods, including maple syrup, acai and goji berries, to make a total of 326 foods.

This table of ORAC values will provide the user with a listing of antioxidant capacity as measured by the oxygen radical absorbance capacity method for a number of food items. When used in tandem with the Special Interest Tables of bioactive phytochemicals developed by NDL, the user can assess the various sources of antioxidants in the food supply.

Aggregation of Data

The data were aggregated where possible to match the food descriptions in the USDA National Nutrient Database for Standard Reference (SR). Subsequently, the mean value (mg/100g), standard error of the mean (SEM), minimum (Min), and maximum (Max.) values were determined for each food and ORAC component value. Mean values are weighted by the number of samples reported among the various studies used. The weighted mean is, in turn, used to calculate the standard error based on the total number of samples in each aggregated food. Standard error was not calculated if the number of samples reported was less than three. Minimum and maximum values are not reported when the number of samples equals one. Similarly, if an author reported analyzing multiple samples, but provided only a mean value with no statistical data, the number of samples was considered as one and standard error, minimum, and maximum values are not reported. If an author reported a mean and standard error, and no other source of data was available for that food item, the mean and standard error are reported, but the minimum and maximum values are blank.

Data Quality Evaluation

The data were evaluated for quality using the USDA's Data Quality Evaluation System (DQES) developed by scientists at the NDL as part of the Nutrient Databank System (10). These procedures were based on criteria described earlier (9, 15) and modified for the first release in 2003 of the flavonoid database (11). The five categories of documentation which were evaluated included: sampling plan, sample handling, number of samples, analytical method, and analytical quality control. NDL modified the criteria for the sampling plan rating at the aggregation stage to accommodate data from international sources. For aggregated data which included data from countries other than the United States, the number of countries replaced the number of regions within a country. The analytical method developed by Prior et al (17) was used as the reference method for evaluating analytical methods from other published sources. This method uses fluorescein as the fluorescent probe and assays hydrophilic as well as lipophilic antioxidants. Analytical data from literature based on methods that used β-phycoerythrin (β-PE) as the probe were not used in this compilation as β-PE may produce inconsistent results in some foods, is not photostable, and may involve nonspecific protein binding with polyphenols (16).

The information presented in each reviewed paper was evaluated for each category. Those data could receive a rating ranging from 0 to 20 points per category. The ratings for each of the five categories were summed to yield a quality index (QI) with the maximum possible score of 100 points. A confidence code (CC) is derived from the QI and is an indicator of the relative quality of the data and the reliability of a given mean. The CC was assigned as indicated in Table 1. The CC appears next to each food and specific component in the ORAC data table.

Table 1.—Confidence Codes (CC) derived from Quality Index (QI)

QI Points	CC
75-100	A
74-50	B
49-25	C
<25	D

Estimation of Missing Values

Some analytical studies reported only H-ORAC or Total-ORAC values. If that was the only data source for that particular food, values for other ORAC components were not imputed. Similarly, missing values were not imputed from other forms of the food (cooked, canned etc.) or other similar foods due to large variability in the ORAC values. If only H-ORAC, was reported, that value was assumed for Total-ORAC, as the values for L-ORAC are, with the exception of a few foods, very low compared to the H-ORAC value.

When data from more than one source for the same food were aggregated, the missing ORAC components were imputed by averaging the available values from other sources for that component. An imputed value was calculated only when two or more values were available for the particular component in the aggregate. Generally, imputing was necessary for the L-ORAC component and occasionally, for both H- and L-ORAC components when only Total-ORAC values were reported by a particular data source. If there were many missing values for L-ORAC for a particular food item, and only one value was available to impute a missing value, the imputing step was not performed. In these cases, the single available value for L-ORAC **was** relatively small compared to the level of the H-ORAC value, and therefore, is not reported. Where imputed values were used in the calculation of the summary statistics, an asterisk appears next to the appropriate parameter in the table.

Format of the Database

ORAC values are reported for hydrophilic-ORAC (H-ORAC), lipophilic-ORAC (L-ORAC), Total-ORAC, and total phenolics (TP). H-ORAC, L-ORAC and total-ORAC are reported in µmol of Trolox Equivalents per 100 grams (µmolTE/100 g), while TP is reported in mg gallic acid equivalents per 100 grams (mgGAE/100 g). The mean value (mg/100g), standard error of the mean (SEM), minimum (Min), and maximum (Max.) values are reported for each food item and ORAC component value. The CC appears next to each food and specific component in the ORAC data table. Standard error was not calculated if the number of samples reported was less than three. Minimum and maximum values are not reported when the number of samples equals one. Other conditions where full statistical information is not provided are described above.

Each food item was given a Nutrient Data Bank (NDB) number, the five digit numerical code used in the SR to identify each unique food entry if it matches a food in SR. As the data came from various sources both in the United States and other countries, there are a number of foods which are not included in the SR database. Temporary NDB numbers, beginning with either "97" or "99", were assigned to foods that are not included in the SR. While efforts were made to assign the same "temporary" NDB Numbers to the same foods as in other Special Interest Databases, some numbers may have been used to encode different foods in other Special Interest Databases produced by the NDL, and therefore may not be unique.

A reference number corresponding to a publication in the sources of data section of the documentation is included in the table for each food and component. The USDA Database for the Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods, Release 2 contains ORAC values for **326** food items, arranged in alphabetical order within food groups and is presented as a PDF file. A user will need the Adobe® Acrobat® reader to view the report of the database.

For those users who can use the data in a database format, the ORAC database is also available as a Microsoft® Access database (ORAC10_R2.mdb). This database follows the same structure as that used for the SR. This will allow the user to use the database on his/her own computer with other applications that can read/access Microsoft® Access files. The files in the database are as follows:

Food Description File (file name = ORAC_DES). This file (Table 2) contains the descriptions of the food items. For those items in the SR* additional information (e.g., common names, percentage, and description of refuse) can be obtained by linking this table to the corresponding table in SR.

- Links to the Food Group Description file by FdGrp_Cd
- Links to the ORAC Data file by NDB No.

Table 2.—Food Description File Format

Field Name	Description
NDB_No†	5-Digit Nutrient Databank number that uniquely identifies a food item. Foods in the Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods, Release 2 which do not have corresponding entries in SR* are assigned NDB Nos. starting with either '99' or '97'.
FDGrp_Cd	4-digit code indicating food group to which the food item belongs
Long_Desc	Description of the food item

* For more information on SR, see the NDL Web site (http://www.ars.usda.gov/nutrientdata) or contact the Nutrient Data Laboratory, 10300 Baltimore Avenue, Bldg. 005, Rm. 107, BARC-WEST, Beltsville, MD 20705. Tel. No. 301-504-0630, e-mail: ndlinfo@ars.usda.gov.
†Primary key for the food description file

Food Group Description File (file name = FD_GROUP). This file (Table 3) contains a list of food groups used in the ORAC database and their descriptions.

- Links to the Food Description file by FdGrp_Cd

Table 3.—Food Group Description File Format

Field Name	Description
FdGrp_Cd*	4-digit code identifying a food group. Only the first 2 digits are currently assigned. In the future, the last 2 digits may be used. Codes may not be consecutive.
FdGrp_Desc	Name of food group

* Primary key for the Food Group Description file.

ORAC Data File (file name = ORAC_DATA). This file (Table 4) contains the ORAC values and information about the values, including statistical information, confidence codes, and sources of data.

- Links to the Food Description file by NDB No.
- Links to the Nutrient Definition file by Nutr. No.
- Links to the Sources of Data file by DataSrc_ID through the Data Source Link file

Table 4.—ORAC Data File Format

Field Name	Description
NDB No.*	5-Digit Nutrient Databank number
Nutr_No*	Unique 3-digit identifier code for each component
Nutr_Val	The ORAC value, edible portion, per 100 g. H-ORAC, L-ORAC and total-ORAC are reported in µmol of Trolox Equivalents (µmolTE/100 g); TP is reported in mg gallic acid equivalents (mgGAE/100 g)
Num_Data_Pts	Number of data points used in calculating the value and SE
Std_Error	Standard error of the mean; null if could not be calculated
Min	Minimum value from data points used
Max	Maximum value from data points used
CC	Confidence Code, designated as A, B, C, or D as determined through the DQES

* Primary keys for ORAC Data file.

Nutrient Definition File (file name = NUTR_DEF). This file provides (Table 5) the 3-digit nutrient number and the description of the component.

- Links to the Nutrient Data file by Nutr_No.

Table 5.—Nutrient Definition File Format

Field Name	Description
Nutr_No*	Unique 3-digit identifier code
NutDesc	Name of the component
Tagname	International Network of Food Data Systems (INFOODS) Tagnames (12). A unique abbreviation for a nutrient/food component developed by INFOODS to aid in the interchange of data
Units	Units of measure (e.g. mg)

* Primary key for Nutrient Definition file.

Sources of Data Link File (file name = DATSRCLN). This file (Table 6) is used to link the Nutrient Data file with the Sources of Data file. It is needed to resolve the many-to-many relationship between the two files.

- Links to the Nutrient Data file by NDB No. and Nutr_No.
- Links to the Sources of Data file by DataSrc_ID.

Table 6.—Sources of Data Link File Format

Field Name	Description
NDB_No*	5-digit Nutrient Databank number
Nutr_No*	Unique 3-digit identifier code for a nutrient
DataSrc_ID*	Unique ID identifying the reference/source

* Primary keys for the Sources of Data Link file.

Sources of Data File (file name = DATA_SRC). This file (Table 7) provides a citation to the DataSrc_ID in the Sources of Data Link file.

- Links to ORAC Data file by NDB No. through the Sources of Data Link file

Table 7.—Sources of Data File Format

Field Name	Description
DataSrc_ID*	Unique number identifying the reference/source
Authors	List of authors for a journal article or name of sponsoring organization for other documents
Title	Title of article or name of document, such as a report from a company or trade association
Year	Year article or document was published
Journal	Name of the journal in which the article was published
Vol	Volume number for journal articles, books, or reports
Start_Page	Starting page number of article/document
End_Page	Ending page number of article/document

* Primary key for the Sources of Data file.

Sources of data

A complete list of the data sources from which the ORAC values in the database were obtained is provided and corresponds to the information provided in the "Sources of Data" file (Table 7). It is also referenced in the Reference No. column in the data tables. Published references list authors, title, and journal citation. Sources of unpublished data are also provided.

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