

Flavonoid Values for USDA Survey Foods and Beverages 2007-2010

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CONTENTS

LIST OF ACRONYMS	4
WHAT PRODUCTS ARE INCLUDED IN THE FLAVONOID VALUES FOR USDA SURVEY FOODS AND BEVERAGES 2007-2010?	5
What's new in the Flavonoid Values for USDA Survey Foods and Beverages 2007-2010?	5
Who developed the Flavonoid Values for USDA Survey Foods and Beverages?	6
THE FLAVONOID DATABASE	7
What is the Flavonoid Database?	7
Context for understanding the contribution of the Flavonoid Database to existing knowledge	8
How is the Flavonoid Database related to FDB-EXP, FNDDS, and other USDA databases? .	9
How can I obtain the Flavonoid Database?.....	12
How were flavonoid values in the Flavonoid Database calculated?	12
<i>Tea codes: Nutrient profile based on composite</i>	<i>13</i>
<i>Minor ingredients: "5-percent rule" and exceptions</i>	<i>13</i>
<i>Isoflavone considerations</i>	<i>16</i>
<i>Retention factors for cooked foods.....</i>	<i>16</i>
What is the structure of the Flavonoid Database?.....	17
Flavonoid Database file formats	18
<i>Main food descriptions (MainFoodDesc)</i>	<i>18</i>
<i>Flavonoid values (FlavVal).....</i>	<i>19</i>
<i>Flavonoid descriptions (FlavDesc)</i>	<i>20</i>
Limitations of the Flavonoid Database	21
THE FLAVONOID INTAKE DATA FILES.....	22
What are the Flavonoid Intake Data Files?	22
How can I obtain the Flavonoid Intake Data Files?	22
Flavonoid Intake Data Files description and format	22
LITERATURE CITED.....	28

LIST OF ACRONYMS

FDB-EXP = USDA's Expanded Flavonoid Database for the Assessment of Dietary Intakes

FNDDS = USDA Food and Nutrient Database for Dietary Studies

FSRG = USDA Food Surveys Research Group

NHANES = National Health and Nutrition Examination Survey

SR = USDA National Nutrient Database for Standard Reference

USDA = U.S. Department of Agriculture

WWEIA = What We Eat in America

WHAT PRODUCTS ARE INCLUDED IN THE FLAVONOID VALUES FOR USDA SURVEY FOODS AND BEVERAGES 2007-2010?

- **Database of Flavonoid Values for USDA Food Codes 2007-2010** - Called the “Flavonoid Database” for short (filename = Flavonoid_Database_0710), this database provides flavonoid values for all foods/beverages in the USDA Food and Nutrient Database for Dietary Studies (FNDDS) versions 4.1 and 5.0 (1), which correspond to dietary data from What We Eat in America (WWEIA), National Health and Nutrition Examination Survey (NHANES) 2007-2008 and 2009-2010 (2), respectively.
- **Flavonoid Intake Data Files from What We Eat in America (WWEIA), National Health and Nutrition Examination Survey (NHANES) 2007-2010** - Called the “Flavonoid Intake Data Files” for short, these four SAS[®] data files include:
 - For each food/beverage report, the amounts of 29 individual flavonoids, 6 flavonoid classes, and total flavonoids consumed on day 1 (flav_dr1iff_0710.sas7bdat) and day 2 (flav_dr2iff_0710.sas7bdat).
 - For each respondent, the total amounts of 29 individual flavonoids, 6 flavonoid classes, and total flavonoids consumed on day 1 (flav_dr1tot_0710.sas7bdat) and day 2 (flav_dr2tot_0710.sas7bdat).
- **Documentation** - This file you are reading (FlavonoidDB_documentation_0710.docx) explains the development of the database and SAS[®] data files listed above.

Please note two important points regarding both the database and the data files:

- 1) For most flavonoids, amounts are reported in aglycones (flavan-3-ols are the exception; see page 7, fourth bullet).*
- 2) Proanthocyanidins (condensed tannins) are not included.*

Both of these factors will affect how flavonoid intake estimates based on these products compare to other published estimates. For more information about the specific flavonoids and their forms, please refer to table 1 (page 7) and text on pages 7 and 8.

What’s new in the Flavonoid Values for USDA Survey Foods and Beverages 2007-2010?

The Flavonoid Database now includes, for each food/beverage, summative totals of all 29 flavonoids and of each flavonoid class. Also, both the Flavonoid Database and the Flavonoid Intake Data Files now include with the flavan-3-ols a variable termed “total catechins,” which is calculated as the sum of (-)-epicatechin, (-)-epicatechin 3-gallate, (-)-epigallocatechin, (-)-epigallocatechin 3-gallate, (+)-catechin, and (+)-gallocatechin.

Who developed the Flavonoid Values for USDA Survey Foods and Beverages?

The USDA Food Surveys Research Group (FSRG) developed the Flavonoid Values for USDA Survey Foods and Beverages using data provided by the USDA Nutrient Data Laboratory. The original release of the Flavonoid Values for USDA Survey Foods and Beverages, which covered only 2007-2008, was supported in part by funding from the Office of Dietary Supplements, National Institutes of Health.

THE FLAVONOID DATABASE

What is the Flavonoid Database?

- Special database of flavonoid values for all foods/beverages in the FNDDS 4.1 and 5.0, corresponding to dietary intake data from WWEIA, NHANES 2007-2008 and 2009-2010, respectively.
- Provides the amounts (mg/100 g) of 29 flavonoids in 6 flavonoid classes (table 1) present in each food/beverage. Most (24) of the individual flavonoids in the database are monomers, the 4 theaflavins are dimers, and the thearubigins are polymers.

Table 1 - Flavonoids in the Flavonoid Database

Class	Name	Class	Name	
Anthocyanidins	Cyanidin	Flavanones	Eriodictyol	
	Delphinidin		Hesperetin	
	Malvidin		Naringenin	
	Pelargonidin	Flavones	Apigenin	
	Peonidin		Luteolin	
	Petunidin	Flavonols	Isorhamnetin	
Flavan-3-ols	(-)-Epicatechin		Kaempferol	
	(-)-Epicatechin 3-gallate		Myricetin	
	(-)-Epigallocatechin		Quercetin	
	(-)-Epigallocatechin 3-gallate		Isoflavones	Daidzein
	(+)-Catechin			Genistein
	(+)-Gallocatechin			Glycitein
	Theaflavin			
	Theaflavin-3,3'-digallate			
	Theaflavin-3'-gallate			
	Theaflavin-3-gallate			
Thearubigins				

- Based on USDA's Expanded Flavonoid Database for the Assessment of Dietary Intakes 1.1¹ (3), also known as FDB-EXP.
- The anthocyanidins, flavanones, flavones, flavonols, and isoflavones included in the database are presented as their aglycone forms (without sugars); flavan-3-ols are presented as their actual forms (*personal communication, Dr. Xianli Wu, USDA Nutrient Data Laboratory, March 31, 2016*).
- Neither FDB-EXP nor the Flavonoid Database includes values for the proanthocyanidin content of foods, which can be substantial (4-6). Proanthocyanidin content for selected foods may be found in the USDA Database for the Proanthocyanidin Content of Selected Foods Release 2 (3). They are excluded from the Flavonoid Database because sufficient data are not yet available for the full range of survey foods/beverages.

¹ The version of FDB-EXP 1.1 used in creating the Flavonoid Values for USDA Survey Foods and Beverages 2007-2010 was downloaded from the webpage cited in reference 3 on 2016 March 18.

- The Flavonoid Database was applied to WWEIA, NHANES 2007-2010 dietary data to produce four Flavonoid Intake Data Files, which are described in more detail beginning on page 22.

Context for understanding the contribution of the Flavonoid Database to existing knowledge

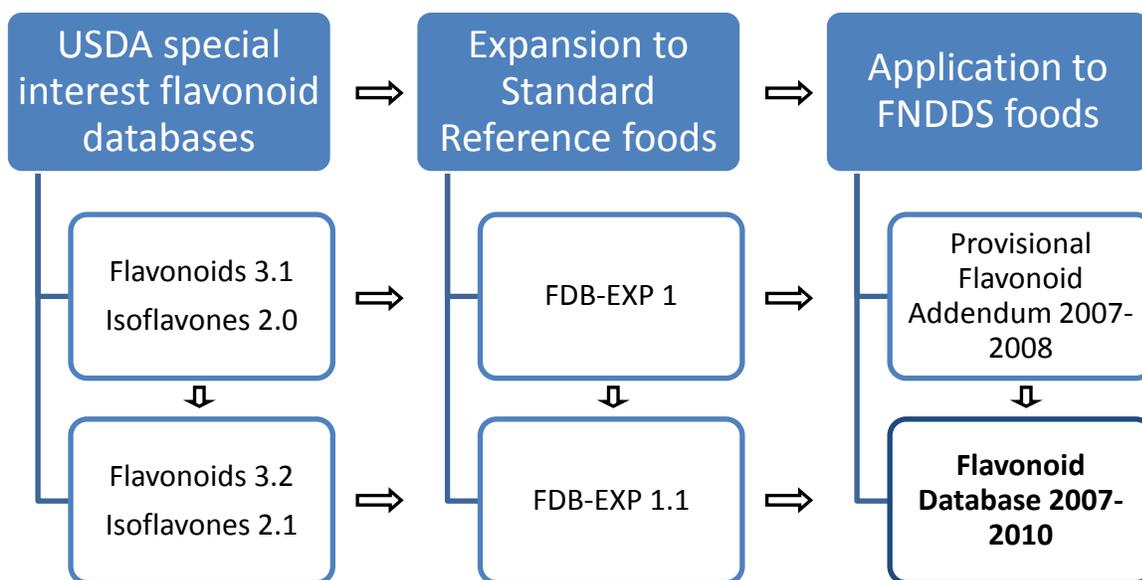
Many chemical compounds in foods and beverages are called “bioactive components,” and some may play important roles in promoting health and preventing disease (7-9). Flavonoids are a large group of bioactive polyphenolic compounds that occur naturally in plants (10-11). Levels of specific flavonoids vary from food to food. Many people are interested in knowing how flavonoids are related to human health, and much research is being done on this topic (7-11).

One factor that has made it difficult for researchers to study relationships between flavonoids and health is the need for more comprehensive databases of flavonoid values in foods and beverages (11-13). To address this deficit, the Food Surveys Research Group (FSRG) has created a database that can be used to estimate flavonoid intakes in the United States. The Flavonoid Database is a step toward closing a gap in the knowledge base about intake of flavonoids. It provides flavonoid values for all foods/beverages in the FNDDS 4.1 and 5.0, the versions of the database used in coding dietary intake data and calculating nutrient intakes from WWEIA, NHANES 2007-2008 and 2009-2010, respectively. By doing that, the Flavonoid Database makes it possible to generate the nationally representative estimates of flavonoid intakes by people of all ages in the United States that are included in this release. (PLEASE NOTE: These estimates include only the flavonoids listed in Table 1; they exclude proanthocyanidins, which may be present in substantial amounts.) The ability to link flavonoid intakes from WWEIA with other health-related data that are included in NHANES opens up new possibilities for research on relationships between flavonoid intakes and health.

How is the Flavonoid Database related to FDB-EXP, FNDDS, and other USDA databases?

Figure 1 illustrates the development of the Database of Flavonoid Values for USDA Food Codes 2007-2010 (“the Flavonoid Database”). Attributes of the Flavonoid Database and its various precursor databases are outlined in table 2.

Figure 1 – Development of the Flavonoid Database 2007-2010



The Flavonoid Database covers the time period 2007 to 2010, thus updating information contained in the Provisional Flavonoid Addendum (14). The Flavonoid Database provides flavonoid values for all foods/beverages in the USDA Food and Nutrient Database for Dietary Studies (FNDDS) versions 4.1 and 5.0 (1).

As specified in table 2, FNDDS 4.1 nutrient profiles are based on information from release 22 of the USDA National Nutrient Database for Standard Reference (SR), which was developed by the USDA Nutrient Data Laboratory (15). FNDDS 5.0 nutrient profiles are based on SR 24 (16).

SR does not yet include flavonoid values. However, the Nutrient Data Laboratory updated and expanded two of their special interest databases (17,18) to create the FDB-EXP release 1 (3). (For more detail about how FDB-EXP was created, read its documentation file, which may be accessed through reference 3.) FDB-EXP provides 29 flavonoid values for over 2,900 SR items that were used as the basis for determining the flavonoid values in the Provisional Flavonoid Addendum and, later, the Flavonoid Database.

Flavonoid values in the Flavonoid Database and in FDB-EXP release 1.1 (3) reflect recent updates to foods and beverages in the USDA Database for the Flavonoid Content of Selected Foods, Release 3.2 (3) and the USDA Database for the Isoflavone Content of Selected Foods, Release 2.1 (3).

Table 2 – Selected attributes of USDA databases related to the Database of Flavonoid Values for USDA Food Codes 2007-2010 (continued on the following page)

<i>Database title (acronym)</i>	<i>Version/title (reference number)</i>	<i>Release date</i>	<i>Corresponding dietary data</i>	<i>Basis for nutrient/ flavonoid data</i>	<i>Number of foods</i>	<i>Number of flavonoids</i>
<u>Flavonoid databases</u>						
USDA Database for the Flavonoid Content of Selected Foods	Release 3.1 (17)	2013	–	Compilation of analytic data (mostly published data)	506	26
	Release 3.2 (3)	Sep. 2015 (slightly revised Nov. 2015)	–	Compilation of analytic data (mostly published data)	506	26
USDA Database for the Isoflavone Content of Selected Foods	Release 2.0 (18)	2008	–	Compilation of analytic data (mostly published data)	557	3
	Release 2.1 (3)	2015	–	Compilation of analytic data (mostly published data)	560	3
USDA Expanded Flavonoid Database for the Assessment of Dietary Intakes (FDB-EXP)	Release 1 (3)	Sep. 2014	–	USDA Database for the Flavonoid Content of Selected Foods, Release 3.1 USDA Database for the Isoflavone Content of Selected Foods, Release 2.0	2,926	29
	Release 1.1 (3)	Dec. 2015	–	USDA Database for the Flavonoid Content of Selected Foods, Release 3.2 USDA Database for the Isoflavone Content of Selected Foods, Release 2.1	2,926	29

<i>Database title (acronym)</i>	<i>Version/title (reference number)</i>	<i>Release date</i>	<i>Corresponding dietary data</i>	<i>Basis for nutrient/ flavonoid data</i>	<i>Number of foods</i>	<i>Number of flavonoids</i>
Flavonoid addendum/database for USDA Survey Foods and Beverages	Flavonoid Values for USDA Survey Foods and Beverages 2007-2008: Provisional Flavonoid Addendum to the FNDDS 4.1 (14)	2014 (slightly revised 2015)	WWEIA, NHANES 2007-2008	FNDDS 4.1 FDB-EXP, release 1	7,174	29
	Database of Flavonoid Values for USDA Food Codes 2007-2010 (14)	2016	WWEIA, NHANES 2007-2010	FNDDS 5.0* FDB-EXP, release 1.1	7,273**	29, plus class and overall totals
<i>Other databases</i>						
Food and Nutrient Database for Dietary Studies (FNDDS)	4.1 (1)	2010	WWEIA, NHANES 2007-2008	SR, Release 22	7,174	0
	5.0 (1)	2012	WWEIA, NHANES 2009-2010	SR, Release 24	7,253 = 7,174 + 99 new -20 discontinued	0
USDA National Nutrient Database for Standard Reference (SR)	Release 22 (15)	2009	–	–	7,538 (2,926 used in FNDDS)	0
	Release 24 (16)	2011	–	–	7,906 (2,926 used in FNDDS)	0

*As discussed in paragraph 3 of the section headed "How were flavonoid values in the Flavonoid Database calculated?" on page 12, a limited number of foods in the Flavonoid Database have flavonoid profiles that are based on information from FNDDS 4.1.

**Food codes that were new in 2009-2010 were added to the Flavonoid Database, but those discontinued in 2009-2010 were not removed.

How can I obtain the Flavonoid Database?

You can download this database from the FSRG website (14). It is available in 3 formats – ASCII, Microsoft Access®, and SAS®. It includes 3 tables or data files – Main Food Descriptions, Flavonoid Values, and Flavonoid Descriptions. Each version of the database is downloadable as a single self-extracting executable PKZip® data file that contains all three tables or data files and the documentation.

How were flavonoid values in the Flavonoid Database calculated?

For the most part, flavonoid values in the Flavonoid Database were calculated in the same way as the nutrient values in the FNDDS were calculated. This process is outlined in the documentation for both versions of the FNDDS that are related to the Flavonoid Database, namely, version 4.1 for 2007-2008 and version 5.0 for 2009-2010. (*The documentation files may be downloaded from the web page cited in reference 1.*) As described in the FNDDS documentation files, nutrient values for FNDDS 4.1 are based on SR22 (15) and those for FNDDS 5.0, on SR24 (16). Data for about 3,000 items in SR were used to determine the nutrient values for the over 7,000 foods in each version of the FNDDS. For many items in FNDDS, nutrient profiles were calculated using more than one SR item. The specific SR items that were used to generate values for each survey food code in FNDDS, and their proportions, are identified in the FNDDS-SR Links files of FNDDS 4.1 and 5.0.

SR items were also used in calculating flavonoid values for the Flavonoid Database. In most cases, the same SR items that had been used to create the FNDDS nutrient values were used to create the Flavonoid Database values. However, there were a few differences.

The source of flavonoid values for the 2007-2010 Flavonoid Database was FDB-EXP 1.1 (3). The original release of FDB-EXP (release 1; reference 3) contained every SR22 item used in FNDDS 4.1, but FDB-EXP release 1.1 does not contain all of the SR24 items used in FNDDS 5.0; rather, it contains the same SR codes as the original release with some updated estimates of flavonoid content. If a food code in FNDDS 5.0 was new in 2009-2010 and had a nutrient profile based on an SR24 item that is not contained in FDB-EXP 1.1, that food's flavonoid profile is the same as the profile for the most similar food. If a food code in FNDDS 5.0 had been present in FNDDS 4.1 but its nutrient profile had been updated for FNDDS 5.0 based on an SR24 item that is not contained in FDB-EXP 1.1, the 2007-2008 Provisional Flavonoid Addendum profile for that food has been retained. For food codes that were discontinued between 2007-2008 (FNDDS 4.1) and 2009-2010 (FNDDS 5.0), Provisional Flavonoid Addendum profiles have also been retained.

Sometimes the set of FNDDS-SR Links providing the documentation for the 65 nutrients/components for an item in FNDDS was not the best match for calculating flavonoid values for that item. To assure more representative flavonoid values, it was necessary to modify existing FNDDS-SR links for selected items. In some cases, such as for tea, a somewhat different set of SR items was used to calculate the flavonoid values for the Flavonoid Database than had been used to calculate nutrient values for the FNDDS. In other cases, FNDDS-SR

Links were changed somewhat in order to ensure the consistency of flavonoid values across related foods. Some of these changes, as well as other considerations, are described below.

Tea codes: Nutrient profile based on composite

Black tea and green tea differ considerably in their flavonoid profiles (*see the documentation for USDA Database for the Flavonoid Content of Selected Foods, release 3.2, available from reference 3*). Black tea is higher in theaflavins and thearubigins, and green tea is higher in catechins, epicatechins, and epigallocatechins. However, when the WWEIA, NHANES 2007-2010 data were collected and coded, no SR code for green tea was available, and, consequently, black and green tea reports were both assigned FNDDS codes with nutrient values based on SR information for black tea alone. The differing flavonoid contents of green and black tea necessitated the addition of a new SR code for green tea. In the Flavonoid Database, FNDDS codes for tea have flavonoid values derived from a composite consisting of 84% black tea and 16% green tea that is based on published market share data for the year 2013².

Note for researchers collecting their own dietary intakes with the intention of measuring flavonoid intakes: It is strongly encouraged that you query respondents who report tea as to the type of tea consumed. If you do so, then for tea reports only, we suggest that you apply the flavonoid profiles for green tea and black tea that are available in FDB-EXP (3) at this writing, rather than those in the Flavonoid Database, in order to obtain more accurate individual flavonoid intakes specific to the type of tea consumed. Beginning in 2013, if a participant in WWEIA, NHANES reports drinking brewed tea, a follow-up question about the type of tea is asked (“Was it made from black tea, green, herbal, ... or something else?”)

Minor ingredients: “5-percent rule” and exceptions

For many foods in the Flavonoid Database, flavonoid values were based on a combination of multiple items (“ingredients”) from the FDB-EXP. When the USDA Nutrient Data Laboratory calculated flavonoid values for the FDB-EXP, they omitted any ingredient that accounted for less than five percent of the weight of the food (3), except when the ingredient was high in flavonoids and likely to be a major contributor of flavonoids, such as cocoa powder (alkalinized or regular), soy protein isolate, or soy flour. The same “5-percent rule” and the same exceptions (with some additions, as outlined in table 3) were applied in the development of the Flavonoid Database, for the following reasons:

- In WWEIA, NHANES, the protocols for interviewing and subsequent coding are designed to capture complete information on intake of macronutrients, vitamins, and minerals. The protocols are not designed to maximize information about every specific ingredient, especially not ingredients that do not provide a significant amount of any of those components.

² See reference 21 in the documentation for the Provisional Flavonoid Addendum (19).

- Respondents often do not know details about minor ingredients in the foods and beverages they consume. This is especially relevant to commercially prepared foods, which account for a growing percentage of all food reports.
- Often a single food code in the Flavonoid Database may represent a variety of foods that differ in the presence/absence of high-flavonoid ingredients such as seasonings and flavorings. Those ingredients may or may not be included in the “recipes” for these food codes.

In addition to the exceptions to the 5-percent rule that were made in the creation of the FDB-EXP, a number of other exceptions were made when assigning flavonoid values to foods in the Flavonoid Database. Minor ingredients were NOT omitted that (a) are concentrated sources of at least one of the flavonoids of interest and (b) were asked about in the WWEIA, NHANES 2007-2010 dietary interview and/or are common recipe ingredients used consistently in many foods in the FNDDS/Flavonoid Database. Ingredients in FNDDS foods that met at least one of these criteria were always included in calculating flavonoid values even when they accounted for less than five percent of an item’s total weight. These ingredients are shown in table 3, along with the flavonoids that are affected.

Table 3 - Ingredients included in calculating flavonoid values even when present in small amounts

<i>Ingredient</i>	<i>Relevant flavonoid(s)</i>	
	<i>Class</i>	<i>Name</i>
<i>Cocoa/chocolate</i>	Flavan-3-ols	(-)-Epicatechin (+)-Catechin
<i>Tea</i>	Flavan-3-ols	(-)-Epicatechin (-)-Epicatechin 3-gallate (-)-Epigallocatechin (-)-Epigallocatechin 3-gallate (+)-Catechin (+)-Gallocatechin Theaflavin Theaflavin-3,3'-digallate Theaflavin-3'-gallate Theaflavin-3-gallate Thearubigins
	Flavonols	Kaempferol Myricetin Quercetin
<i>Soy-based products</i>	Isoflavones	Daidzein Genistein Glycitein
<i>Onions</i>	Flavonols	Isorhamnetin Quercetin
<i>Chili peppers</i>	Flavones	Luteolin
	Flavonols	Quercetin
<i>Sweet peppers</i>	Flavones	Luteolin
<i>Berries</i>	Anthocyanidins	Cyanidin Delphinidin Malvidin Pelargonidin Peonidin Petunidin
	Flavonols	Myricetin
<i>Lemon (juice, peel)</i>	Flavanones	Eriodictyol Hesperetin
<i>Dark-green leafy vegetables</i>	Flavonols	Isorhamnetin Kaempferol Quercetin
<i>Celery</i>	Flavones	Apigenin Luteolin

Isoflavone considerations

A preliminary review of the data indicated that in 2007-2010 the predominant source of isoflavones by far was soy-based foods/beverages. Top contributors of isoflavones were items that were composed predominantly of soy ingredients, for example, soy-based infant formula, soy milk, and tofu. For items with isoflavones provided primarily by major ingredients, the isoflavone values that were present in the FDB-EXP were retained.

Most of the remainder of isoflavone intake came from functional ingredients, meaning ingredients that are added to a food/beverage to serve a particular purpose. Many items contain soy additives that serve as stabilizers or emulsifiers. However, some items that are alike in most ways but differ in the presence/absence of soy-based functional ingredients are coded using the same FNDDS code and thus are given the same flavonoid profile. For example, two different brands of beef frankfurter would be coded with the same FNDDS code, even if one brand has soy ingredients and the other does not.

For those reasons, isoflavone values were set to zero when (a) the FDB-EXP contained non-zero isoflavone values for a given SR code, but (b) isoflavones in such a food would be provided by a functional ingredient that may or may not be present in all foods of that type. However, there were a few exceptions. Isoflavone values were retained for doughnuts since nearly all contain soy-based functional ingredients (20). Isoflavones were also retained for soy-containing nutrition bars, because collection of brand name information during the dietary intake made it possible to assign bars that contained soy to different food codes from those that did not contain soy.

Isoflavone values for eggs were set to zero because they were based on limited data collected in two very specific geographical regions³. The effect of omitting eggs from calculation of isoflavone intakes *per se* is likely to be negligible, though it does affect estimates of the percentage of individuals with zero isoflavone intake.

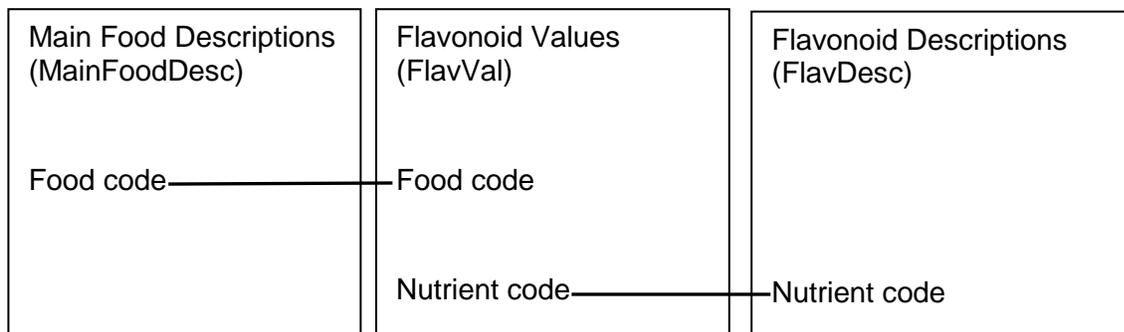
Retention factors for cooked foods

Retention factors to account for cooking method were applied to the flavonoid values in a manner consistent with the method described in the FDB-EXP documentation (3). Briefly, for moist-heat cooking methods, a loss of 15% was applied to flavonols, flavanols, flavanones, and flavones and one of 50% to anthocyanidins. No loss was assumed for dry-heat cooking methods such as baking. No retention factors were applied to isoflavones, because analytical values were available for both raw and cooked/processed versions of most foods that contain isoflavones.

³ See references 31 and 76a in the documentation for the USDA Database for the Isoflavone Content of Selected Foods, Release 2.1 (3).

What is the structure of the Flavonoid Database?

The Flavonoid Database contains 3 data files or tables. The diagram below illustrates the interrelationships among them.



The food code field and the nutrient code field serve as linking fields between different tables in the database.

The Main Food Descriptions file has one record for each food code. There are 7,273 food codes in all. The format of the Main Descriptions file is provided on page 18.

The Flavonoid Values file contains 37 records for each food code – 1 record for each of the 29 individual flavonoids that are included (see table 1 on page 7) and 1 for each of the 8 totals/subtotals, namely, total flavonoids (the sum of all 6 classes), total anthocyanidins, total flavan-3-ols, total flavanones, total flavones, total flavonols, total isoflavones, and total catechins (monomeric flavan-3-ols only). There are 269,101 records in all. Each record is linked to the Main Food Descriptions through the 8-digit food code and to the Flavonoid Descriptions through the 3 or 4-digit nutrient code. The format of the Flavonoid Values file is provided on page 19.

The Flavonoid Descriptions file contains 37 records – 1 record for each of the 29 individual flavonoids and 1 for each total/subtotal. The format of the Flavonoid Descriptions file is provided on page 20.

Flavonoid Database file formats

Main food descriptions (MainFoodDesc)

The main food description is the primary (usually generic) complete description identified by a unique 8-digit food code. The food code links the main food description to other database files. The file has one record for each food code (7,273 records in all).

Table 4 - Format of Main Food Descriptions file¹

<i>Field Name</i>	<i>Field Type</i>	<i>Description</i>
<i>Food code</i> ‡	N 8*	A unique 8-digit number assigned to a particular main food description.
<i>Start date</i>	D (MM/DD/YYYY)	For the Flavonoid Database, all start and end dates are the same (1/1/2007 and 12/31/2010, respectively). They correspond to the time period for WWEIA, NHANES 2007-2010.
<i>End date</i>	D (MM/DD/YYYY)	
<i>Main food description</i>	A 200	A complete description for a food, often including preparation method (e.g., boiled) and original form of the food (e.g., from frozen); usually generic in nature.

¹The only difference between the Main Food Descriptions File in the Flavonoid Database and the one in the FNDDS 5.0 is the inclusion in the Flavonoid Database of 20 food codes that were discontinued between FNDDS versions 4.1 and 5.0.

‡Linking field; used to link different files within the database.

N = numeric field. Number following field type indicates field length.

*Indexed field (holds values by which the file is ordered). Although ASCII delimited files do not have indexes, they are identified in this document to show the order of records.

A = alphanumeric field. Number following field type indicates field length.

Flavonoid values (FlavVal)

For each food code in the Main Food Descriptions file, the Flavonoid Values file contains one record for each of the 29 individual flavonoids, one for total flavonoids (the sum of all 6 classes), one for each class total (i.e., total anthocyanidins, total flavan-3-ols, total flavanones, total flavones, total flavonols, and total isoflavones), and one for the subtotal called “total catechins” (monomeric flavan-3-ols only). Thus, this file includes 269,101 records in all. Flavonoids are identified by the nutrient code, which links to the Flavonoid Descriptions file.

Table 5 - Format of Flavonoid Values file

Field Name	Field Type	Description
Food code‡	N 8*	A unique 8-digit number assigned to a particular main food description.
Nutrient code‡	N 4*	Identifies an individual flavonoid or a total/subtotal. For individual flavonoids, the nutrient code corresponds to Nutr_No in FDB-EXP (3). Individual flavonoids have a 3-digit nutrient code, whereas flavonoid totals/subtotals have a 4-digit nutrient code.
Start date	D (MM/DD/YYYY)*	For the Flavonoid Database, all start and end dates are the same (1/1/2007 and 12/31/2010, respectively). They correspond to the time period for WWEIA, NHANES 2007-2010.
End date	D (MM/DD/YYYY)	
Nutrient value	N 10.2	Amount of nutrient (flavonoid) in 100 grams edible portion of the food; follows conventions in FDB-EXP (3).

‡Linking field; used to link different files within the database.

N = numeric field. Number following field type indicates field length; number after decimal point indicates number of decimal places.

*Indexed field (holds values by which the file is ordered). Although ASCII delimited files do not have indexes, they are identified in this document to show the order of records.

Flavonoid descriptions (FlavDesc)

This file contains the name (flavonoid description) for each flavonoid or total/subtotal (nutrient code) included in the Flavonoid Values file (37 records in all). The nutrient codes, flavonoid descriptions, units of expression, and number of decimal places to which values are expressed are consistent with similar fields in the FDB-EXP.

Table 6 - Format of Flavonoid Descriptions file

Field Name	Field Type	Description
Nutrient code‡	N 4*	Identifies an individual flavonoid or a total/subtotal. For individual flavonoids, the nutrient code corresponds to Nutr_No in FDB-EXP (3). Individual flavonoids have a 3-digit nutrient code, whereas flavonoid totals/subtotals have a 4-digit nutrient code.
Flavonoid description	A 45	Name of the flavonoid or total/subtotal.
Flavonoid class	A 45	The class of flavonoids to which the individual flavonoid belongs.
Tagname	A 15	The nutrient or food component name or “tag” assigned by INFOODS, the International Network of Food Data Systems, for international interchange of nutrient data (21). This is a missing value for 10 of the 29 flavonoids included in the Flavonoid Database, namely, for nutrient code 743, pelargonidin; 749, (+)-catechin; 753, (-)-epigallocatechin 3-gallate; 755, theaflavin; 756, thearubigins; 758, eriodictyol; 785, isorhamnetin; 791, theaflavin-3,3'-digallate; 792, theaflavin-3'-gallate; and 793, theaflavin-3-gallate.
Unit	A 10	The measurement unit in which values for the nutrient are expressed.
Decimals	N 2	The number of decimal places to which the nutrient (flavonoid) value is expressed, following conventions in FDB-EXP (3).

‡Linking field; used to link different files within the database.

N = numeric field. Number following field type indicates field length.

*Indexed field (holds values by which the file is ordered). Although ASCII delimited files do not have indexes, they are identified in this document to show the order of records.

A = alphanumeric field. Number following field type indicates field length.

Limitations of the Flavonoid Database

- Papers that include estimates of flavonoid intake based upon values in the Flavonoid Database should contain a statement about the limited amount of analytical data in its source database, the FDB-EXP. Only a small percentage ($\approx 3\%$) of the flavonoid values in the FDB-EXP are analytical values, though it is noteworthy that the SR items that do have analytical values provide the basis for a large proportion of flavonoid intake overall. About 24% of values in the FDB-EXP were imputed based on data for similar foods. The majority ($\approx 73\%$) of values were assigned logical zeroes, that is, a value was assumed to be zero when the flavonoid in question was not expected to be present in a particular food item. Assignment of flavonoid values to foods is explained in detail in the FDB-EXP documentation (3).
- The foods and beverages and their flavonoid profiles that are contained in the Flavonoid Database represent items as available in the marketplace and consumed in 2007-2010. Some underlying assumptions that are correct for 2007-2010 may not be correct for other time periods. For that reason, researchers should exercise caution about applying Flavonoid Database values to dietary data collected in other time periods and in interpreting results, and this issue should be included as a limitation of the analysis.
- As described in the section "Isoflavone considerations," isoflavone values were set to zero when (a) the FDB-EXP contained non-zero isoflavone values for a given SR code, but (b) isoflavones in such an item would be provided by a functional ingredient that may or may not be present in all items of that type. Overall, this conservative approach of setting to zero the isoflavone contributions of the items in question will yield lower estimates of isoflavone intake.
- Retention of flavonoids following processing (cooking, storage, etc.) varies widely, and is dependent not only on the flavonoid of interest but also the particular food (22). It is possible (and likely) that by applying the same retention factor for a given flavonoid class across all foods, under- and overestimation of the flavonoid composition of some foods will occur.

THE FLAVONOID INTAKE DATA FILES

What are the Flavonoid Intake Data Files?

- The result of applying flavonoid values from the Flavonoid Database (14) to dietary intake data from WWEIA, NHANES 2007-2010 (2).
- Provide data used in estimating nationally representative estimates of flavonoid intakes by people of all ages in the United States in 2007-2010.
- Correspond in format and naming convention to the Individual Foods and Total Nutrients files from WWEIA, NHANES.

How can I obtain the Flavonoid Intake Data Files?

You can download these files from the FSRG website (14). Look for the link “Documentation/Database Addendum/Survey Data Files.” The files are in SAS® format. Each downloadable file is a single self-extracting executable PKZip® file that contains a data file and the documentation.

Flavonoid Intake Data Files description and format

The USDA Food Surveys Research Group used the Flavonoid Database and dietary intake data from WWEIA, NHANES 2007-2010 to create four SAS® format files containing flavonoid intakes per food/beverage report and per day. The resulting files allow researchers to analyze flavonoid intake separately or, through the key identifiers, together with the nutrients and dietary components already available from WWEIA and/or other NHANES data.

Table 7 lists the four Flavonoid Intake Data Files. Flavonoid values for each food/beverage reported in the WWEIA, NHANES individual foods files were calculated as the amount of the food in the original file times the flavonoid values (mg per 100 g) for the specific food code. The individual foods flavonoid files contain, for each food/beverage reported on Day 1 and Day 2, the amounts of each of the 29 individual flavonoids, total flavonoids (the sum of all 6 classes), total anthocyanidins, total flavan-3-ols, total flavanones, total flavones, total flavonols, total isoflavones, and total catechins (monomeric flavan-3-ols only). The total flavonoid files provide, for each survey participant on Day 1 and Day 2, the daily total intakes of the 29 individual flavonoids, total flavonoids (the sum of all 6 classes), total anthocyanidins, total flavan-3-ols, total flavanones, total flavones, total flavonols, total isoflavones, and total catechins (monomeric flavan-3-ols only).

The 2007-2010 Flavonoid Intake Data Files are identical in most respects to the files previously released for 2007-2008. One difference is the addition in 2007-2010 of a variable termed “total catechins,” which is calculated as the sum of (-)-epicatechin, (-)-epicatechin 3-gallate, (-)-epigallocatechin, (-)-epigallocatechin 3-gallate, (+)-catechin, and (+)-gallocatechin.

Another new variable included on each of the flavonoid intake data file records is the data release number, which identifies the two-year survey cycle. Records from the 2007-2008 survey cycle have a value of '5,' and those from the 2009-2010 survey cycle have a value of '6.' The data from the two survey cycles may be either analyzed separately or combined to form a four-year sample. For guidance in combining two NHANES survey cycles, please refer to the *National Health and Nutrition Examination Survey: Analytic Guidelines, 1999-2010* available from: http://www.cdc.gov/nchs/nhanes/survey_methods.htm. The advice on combining two-year Mobile Examination Center (MEC) sample weights also applies to the dietary sample weights that will most often be used for dietary intake analysis.

Table 7 - Flavonoid Intake Data Files created using the Flavonoid Database and the dietary intake files of What We Eat in America, National Health and Nutrition Examination Survey (WWEIA, NHANES) 2007-2010

<i>Type of data</i>	<i>Name (description) of Flavonoid Intake Data File</i>	<i>Key identifier(s)</i>	<i>Number of records</i>	<i>Name (description) of corresponding WWEIA, NHANES files</i>
Individual foods	<i>flav_dr1iff_0710.sas7bdat</i> (Day 1 Individual Foods Flavonoid File)	SEQN, DR1ILINE	296,694	DR1IFF_E.xpt and DR1IFF_F.xpt (Day 1 Individual Foods Files)
	<i>flav_dr2iff_0710.sas7bdat</i> (Day 2 Individual Foods Flavonoid File)	SEQN, DR2ILINE	250,482	DR2IFF_E.xpt and DR2IFF_F.xpt (Day 2 Individual Foods Files)
Total nutrients	<i>flav_dr1tot_0710.sas7bdat</i> (Day 1 Total Flavonoid File)	SEQN	20,015	DR1TOT_E.xpt and DR1TOT_F.xpt (Day 1 Total Nutrient Files)
	<i>flav_dr2tot_0710.sas7bdat</i> (Day 2 Total Flavonoid File)	SEQN	20,015	DR2TOT_E.xpt and DR2TOT_F.xpt (Day 2 Total Nutrient Files)

Lists of variables in the Flavonoid Intake Data Files are shown in tables 8 and 9. Each of the records in the four files functions as an extension of the corresponding WWEIA, NHANES 2007-2008 or 2009-2010 dietary intake file and contains records for the same individuals and food reports. Documentation for the WWEIA, NHANES 2007-2008 survey data files is found at <http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Dietary&CycleBeginYear=2007> and for 2009-2010 at <http://wwwn.cdc.gov/nchs/nhanes/search/DataPage.aspx?Component=Dietary&CycleBeginYear=2009>.

Table 8. Variables in the Flavonoid Intake Individual Food Files (“per food report” files)

<i>Day 1 variable name</i>	<i>Day 2 variable name</i>	<i>Description¹</i>
seqn	seqn	Respondent sequence number
sddsrvyr	sddsrvyr	Data Release Number
dr1iline	dr2iline	Food/Individual component number
dr1i_fl710	dr2i_fl710	710 Daidzein (mg) [Isoflavones]
dr1i_fl711	dr2i_fl711	711 Genistein (mg) [Isoflavones]
dr1i_fl712	dr2i_fl712	712 Glycitein (mg) [Isoflavones]
dr1i_fl731	dr2i_fl731	731 Cyanidin (mg) [Anthocyanidins]
dr1i_fl740	dr2i_fl740	740 Petunidin (mg) [Anthocyanidins]
dr1i_fl741	dr2i_fl741	741 Delphinidin (mg) [Anthocyanidins]
dr1i_fl742	dr2i_fl742	742 Malvidin (mg) [Anthocyanidins]
dr1i_fl743	dr2i_fl743	743 Pelargonidin (mg) [Anthocyanidins]
dr1i_fl745	dr2i_fl745	745 Peonidin (mg) [Anthocyanidins]
dr1i_fl749	dr2i_fl749	749 (+)-Catechin (mg) [Flavan-3-ols]
dr1i_fl750	dr2i_fl750	750 (-)-Epigallocatechin (mg) [Flavan-3-ols]
dr1i_fl751	dr2i_fl751	751 (-)-Epicatechin (mg) [Flavan-3-ols]
dr1i_fl752	dr2i_fl752	752 (-)-Epicatechin 3-gallate (mg) [Flavan-3-ols]
dr1i_fl753	dr2i_fl753	753 (-)-Epigallocatechin 3-gallate (mg) [Flavan-3-ols]
dr1i_fl755	dr2i_fl755	755 Theaflavin (mg) [Flavan-3-ols]
dr1i_fl756	dr2i_fl756	756 Thearubigins (mg) [Flavan-3-ols]
dr1i_fl758	dr2i_fl758	758 Eriodictyol (mg) [Flavanones]

<i>Day 1 variable name</i>	<i>Day 2 variable name</i>	<i>Description¹</i>
dr1i_fl759	dr2i_fl759	759 Hesperetin (mg) [Flavanones]
dr1i_fl762	dr2i_fl762	762 Naringenin (mg) [Flavanones]
dr1i_fl770	dr2i_fl770	770 Apigenin (mg) [Flavones]
dr1i_fl773	dr2i_fl773	773 Luteolin (mg) [Flavones]
dr1i_fl785	dr2i_fl785	785 Isorhamnetin (mg) [Flavonols]
dr1i_fl786	dr2i_fl786	786 Kaempferol (mg) [Flavonols]
dr1i_fl788	dr2i_fl788	788 Myricetin (mg) [Flavonols]
dr1i_fl789	dr2i_fl789	789 Quercetin (mg) [Flavonols]
dr1i_fl791	dr2i_fl791	791 Theaflavin-3,3'-digallate (mg) [Flavan-3-ols]
dr1i_fl792	dr2i_fl792	792 Theaflavin-3'-gallate (mg) [Flavan-3-ols]
dr1i_fl793	dr2i_fl793	793 Theaflavin-3-gallate (mg) [Flavan-3-ols]
dr1i_fl794	dr2i_fl794	794 (+)-Gallocatechin (mg) [Flavan-3-ols]
dr1i_fl_total	dr2i_fl_total	7000 Flavonoid totals: Sum of all 29 individual flavonoids (mg)
dr1i_fl_antho	dr2i_fl_antho	7100 Flavonoid totals: Anthocyanidins (mg)
dr1i_fl_catechin	dr2i_fl_catechin	7200 Flavonoid subtotal: Catechins (mg) [Flavan-3-ols]
dr1i_fl_3_ols	dr2i_fl_3_ols	7300 Flavonoid totals: Flavan-3-ols (mg)
dr1i_fl_nones	dr2i_fl_nones	7400 Flavonoid totals: Flavanones (mg)
dr1i_fl_ones	dr2i_fl_ones	7500 Flavonoid totals: Flavones (mg)
dr1i_fl_ols	dr2i_fl_ols	7600 Flavonoid totals: Flavonols (mg)
dr1i_fl_iso	dr2i_fl_iso	7700 Flavonoid totals: Isoflavones (mg)

¹The “Description” column includes the nutrient code, flavonoid description, and unit of measure in parentheses. For individual flavonoids and catechins subtotal, the flavonoid class is also listed in square brackets.

Table 9. Variables in the Flavonoid Intake Total Nutrient Files (“per day” files)

<i>Day 1 variable name</i>	<i>Day 2 variable name</i>	<i>Description¹</i>
seqn	seqn	Respondent sequence number
sddsrvyr	sddsrvyr	Data Release Number
dr1drstz	dr2drstz	Dietary recall status
dr1 t_fl710	dr2 t_fl710	710 Daidzein (mg) [Isoflavones]
dr1 t_fl711	dr2 t_fl711	711 Genistein (mg) [Isoflavones]
dr1 t_fl712	dr2 t_fl712	712 Glycitein (mg) [Isoflavones]
dr1 t_fl731	dr2 t_fl731	731 Cyanidin (mg) [Anthocyanidins]
dr1 t_fl740	dr2 t_fl740	740 Petunidin (mg) [Anthocyanidins]
dr1 t_fl741	dr2 t_fl741	741 Delphinidin (mg) [Anthocyanidins]
dr1 t_fl742	dr2 t_fl742	742 Malvidin (mg) [Anthocyanidins]
dr1 t_fl743	dr2 t_fl743	743 Pelargonidin (mg) [Anthocyanidins]
dr1 t_fl745	dr2 t_fl745	745 Peonidin (mg) [Anthocyanidins]
dr1 t_fl749	dr2 t_fl749	749 (+)-Catechin (mg) [Flavan-3-ols]
dr1 t_fl750	dr2 t_fl750	750 (-)-Epigallocatechin (mg) [Flavan-3-ols]
dr1 t_fl751	dr2 t_fl751	751 (-)-Epicatechin (mg) [Flavan-3-ols]
dr1 t_fl752	dr2 t_fl752	752 (-)-Epicatechin 3-gallate (mg) [Flavan-3-ols]
dr1 t_fl753	dr2 t_fl753	753 (-)-Epigallocatechin 3-gallate (mg) [Flavan-3-ols]
dr1 t_fl755	dr2 t_fl755	755 Theaflavin (mg) [Flavan-3-ols]
dr1 t_fl756	dr2 t_fl756	756 Thearubigins (mg) [Flavan-3-ols]
dr1 t_fl758	dr2 t_fl758	758 Eriodictyol (mg) [Flavanones]
dr1 t_fl759	dr2 t_fl759	759 Hesperetin (mg) [Flavanones]
dr1 t_fl762	dr2 t_fl762	762 Naringenin (mg) [Flavanones]
dr1 t_fl770	dr2 t_fl770	770 Apigenin (mg) [Flavones]
dr1 t_fl773	dr2 t_fl773	773 Luteolin (mg) [Flavones]
dr1 t_fl785	dr2 t_fl785	785 Isorhamnetin (mg) [Flavonols]

<i>Day 1 variable name</i>	<i>Day 2 variable name</i>	<i>Description¹</i>
dr1 t_fl786	dr2 t_fl786	786 Kaempferol (mg) [Flavonols]
dr1 t_fl788	dr2 t_fl788	788 Myricetin (mg) [Flavonols]
dr1 t_fl789	dr2 t_fl789	789 Quercetin (mg) [Flavonols]
dr1 t_fl791	dr2 t_fl791	791 Theaflavin-3,3'-digallate (mg) [Flavan-3-ols]
dr1 t_fl792	dr2 t_fl792	792 Theaflavin-3'-gallate (mg) [Flavan-3-ols]
dr1 t_fl793	dr2 t_fl793	793 Theaflavin-3-gallate (mg) [Flavan-3-ols]
dr1 t_fl794	dr2 t_fl794	794 (+)-Galocatechin (mg) [Flavan-3-ols]
dr1 t_fl_total	dr2 t_fl_total	7000 Flavonoid totals: Sum of all 29 individual flavonoids (mg)
dr1 t_fl_antho	dr2 t_fl_antho	7100 Flavonoid totals: Anthocyanidins (mg)
dr1t_fl_catechin	dr2t_fl_catechin	7200 Flavonoid subtotal: Catechins (mg) [Flavan-3-ols]
dr1 t_fl_3_ols	dr2 t_fl_3_ols	7300 Flavonoid totals: Flavan-3-ols (mg)
dr1 t_fl_nones	dr2 t_fl_nones	7400 Flavonoid totals: Flavanones (mg)
dr1 t_fl_ones	dr2 t_fl_ones	7500 Flavonoid totals: Flavones (mg)
dr1 t_fl_ols	dr2 t_fl_ols	7600 Flavonoid totals: Flavonols (mg)
dr1 t_fl_iso	dr2 t_fl_iso	7700 Flavonoid totals: Isoflavones (mg)

¹The “Description” column includes the nutrient code, flavonoid description, and unit of measure in parentheses. For individual flavonoids and catechins subtotal, the flavonoid class is also listed in square brackets.

LITERATURE CITED

1. U.S. Department of Agriculture, Food Surveys Research Group [Internet]. *FNDDS Download Databases* [modified 2015 Aug 20; cited 2016 May 12]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=12068>.
2. U.S. Department of Agriculture, Food Surveys Research Group [Internet]. *What We Eat in America Documentation and Data Sets* [modified 2014 Oct 2; cited 2016 May 12]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=18354>.
3. U.S. Department of Agriculture, Nutrient Data Laboratory [Internet]. *USDA Special Interest Databases on Flavonoids* [includes USDA Database for the Flavonoid Content of Selected Foods Release 3.2, USDA Database for the Isoflavone Content of Selected Foods Release 2.1, USDA Database for the Proanthocyanidin Content of Selected Foods Release 2, and USDA's Expanded Flavonoid Database for the Assessment of Dietary Intakes (both release 1 and release 1.1); updated 2015 Dec 31; cited 2016 May 12]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=24953>.
4. Bai W, Wang C, Ren C. Intakes of total and individual flavonoids by US adults. *Int J Food Sci Nutr*. 2014 Feb 65(1):9-20. doi: 10.3109/09637486.2013.832170.
5. McCullough ML, Peterson JJ, Patel R, Jacques PF, Shah R, Dwyer JT. Flavonoid intake and cardiovascular disease mortality in a prospective cohort of US adults. *Am J Clin Nutr*. 2012. Feb 95(2):454-464. <http://ajcn.nutrition.org/content/95/2/454.long>.
6. Zamora-Ros R, Knaze V, Lujan-Barroso L, Romieu I, Scalbert A, Slimani N, et al. Differences in dietary intake, food sources and determinants of total flavonoids between Mediterranean and non-Mediterranean countries participating in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. *Br J Nutr*. 2013 Apr 28;109(8):1498-507. doi: 10.1017/S0007114512003273.
7. Kris-Etherton PM, Hecker KD, Bonanome A, Coval SM, Binkoski AE, Hilpert KF, Griel AE, Etherton TD. Bioactive compounds in foods: their role in the prevention of cardiovascular disease and cancer. *Am J Med*. 2002 Dec 30;113 Suppl 9B:71S-88S. doi: 10.1016/S0002-9343(01)00995-0.
8. Kumar S, Pandey AK. Chemistry and biological activities of flavonoids: An overview. *Scientific World Journal*. 2013 Dec 29;2013:162750. doi: 10.1155/2013/162750.
9. Pandey KB, Rizvi SI. Plant polyphenols as dietary antioxidants in human health and disease. *Oxid Med Cell Longev*. 2009 Nov-Dec;2(5):270-8. doi: 10.4161/oxim.2.5.9498.
10. Beecher GR. Overview of dietary flavonoids: nomenclature, occurrence and intake. *J Nutr*. 2003 Oct;133(10):3248S-3254S.
11. Erdman JW Jr, Balentine D, Arab L, Beecher G, Dwyer JT, Folts J, Harnly J, Hollman P, Keen CL, Mazza G, Messina M, Scalbert A, Vita J, Williamson G, Burrowes J. Flavonoids and heart health: proceedings of the ILSI North America Flavonoids Workshop, May 31-June 1, 2005, Washington, DC. *J Nutr*. 2007 Mar;137(3 Suppl 1):718S-737S.

12. Bobe G, Peterson JJ, Gridley G, Hyer M, Dwyer JT, Brown LM. Flavonoid consumption and esophageal cancer among black and white men in the United States. *Int J Cancer*. 2009 Sep 1;125(5):1147-1154. doi: 10.1002/ijc.24421.
13. Chun OK, Chung SJ, Song WO. Estimated dietary flavonoid intake and major food sources of U.S. adults. *J Nutr*. 2007 May;137(5):1244-1252.
14. U.S. Department of Agriculture, Food Surveys Research Group [Internet]. *FNDDS Flavonoid Database* [modified 2016 Month Day; cited 2016 Month Day]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=25102>.
15. U.S. Department of Agriculture, Nutrient Data Laboratory [Internet]. *SR22 home page* [USDA National Nutrient Database for Standard Reference, release 22; modified 2015 Sep 30; cited 2016 May 12]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=20960>.
16. U.S. Department of Agriculture, Nutrient Data Laboratory [Internet]. *SR24 home page* [USDA National Nutrient Database for Standard Reference, release 24; modified 2015 Sep 30; cited 2016 May 12]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=22808>.
17. Bhagwat S, Haytowitz DB, Holden JM. *USDA Database for the Flavonoid Content of Selected Foods, Release 3.1* [Internet]. Beltsville, MD: U.S. Department of Agriculture, Nutrient Data Laboratory; Dec. 2013 (slightly revised May 2014) [cited 2016 May 12]. Available from: http://www.ars.usda.gov/SP2UserFiles/Place/12354500/Data/Flav/Flav_R03-1.pdf.
18. Bhagwat S, Haytowitz DB, Holden JM. *USDA Database for the Isoflavone Content of Selected Foods, Release 2.0* [Internet]. Beltsville, MD: U.S. Department of Agriculture, Nutrient Data Laboratory; 2008 [cited 2016 May 12]. Available from: http://www.ars.usda.gov/SP2UserFiles/Place/80400525/Data/isoflav/Isoflav_R2.pdf.
19. Sebastian RS, Goldman JD, Martin CL, Steinfeldt LC, Wilkinson Enns C, Moshfegh AJ. *Flavonoid Values for USDA Survey Foods 2007-2008: Provisional Flavonoid Addendum to the USDA Food and Nutrient Database for Dietary Studies, 4.1, and Flavonoid Intake Data Files from What We Eat in America (WWEIA), National Health and Nutrition Examination Survey (NHANES) 2007-2008* [Internet]. Beltsville, MD: U.S. Department of Agriculture, Food Surveys Research Group; 2014 (slightly revised 2015) [cited 2016 May 17]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=25102>.
20. Horn-Ross PL, Barnes S, Lee M, Coward L, Mandel JE, Koo J, John EM, Smith M. Assessing phytoestrogen exposure in epidemiologic studies: development of a database (United States). *Cancer Causes Control*. 2000 Apr;11(4):289-298.
21. Food and Agriculture Organization of the United Nations [Internet]. *International Network of Food Data Systems (INFOODS): tagnames for food components* [updated 2014 Jun 8; cited 2016 Feb 29]. Available from: <http://www.fao.org/infoods/infoods/standards-guidelines/food-component-identifiers-tagnames/en/>.
22. Rothwell JA, Medina-Remón A, Pérez-Jiménez J, Neveu V, Knaze V, Slimani N, Scalbert A. Effects of food processing on polyphenol contents: a systematic analysis

using Phenol-Explorer data. *Mol Nutr Food Res*. 2015 Jan;59(1):160-170. doi: 10.1002/mnfr.201400494.