Flavonoid Values for USDA Survey Foods and Beverages 2017-2018

Rhonda S. Sebastian, Carrie L. Martin, Joseph D. Goldman, and Alanna Moshfegh

U.S. Department of Agriculture, Agricultural Research Service
Beltsville Human Nutrition Research Center
Food Surveys Research Group
10300 Baltimore Avenue
BARC-West, Building 005, Room 102
Beltsville, Maryland 20705-2350
http://www.ars.usda.gov/nea/bhnrc/fsrg

Suggested citation: U.S. Department of Agriculture, Agricultural Research Service. 2022. *Flavonoid Values for USDA Survey Foods and Beverages 2017-2018.* Food Surveys Research Group Home Page, http://www.ars.usda.gov/nea/bhnrc/fsrg**.**

DISCLAIMERS

Reference to any product, service, process, or method by trade name, trademark, service mark, manufacturer or otherwise is for ease of identification only and does not imply recommendation, endorsement, or approval by, or an association with, the U.S. Department of Agriculture.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, DC 20250-9410 or call (800) 795-3272 (voice), or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Issued July 2022

CONTENTS

Table of Contents

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 = Food Surveys Research Group
NHANES = National Health and Nutrition Examination Survey
FDC = USDA FoodData Central
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 2017-2018?

Three products are included in this release:

- **Database of Flavonoid Values for USDA Food Codes 2017-2018** - Called the "Flavonoid Database" for short; filename = Flavonoid_Database_1718, this database provides flavonoid values for all foods/beverages (n = 7,083) in the USDA Food and Nutrient Database for Dietary Studies (FNDDS) 2017-2018 *(1)*, which corresponds to dietary data from What We Eat in America (WWEIA), National Health and Nutrition Examination Survey (NHANES) 2017-2018 *(2)*.
- **Flavonoid Intake Data Files from What We Eat in America (WWEIA), National Health and Nutrition Examination Survey (NHANES) 2017-2018** - 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_1718.sas7bdat) and Day 2 (flav_dr2iff_1718.sas7bdat).
    - For each respondent, the total amounts of 29 individual flavonoids, 6 flavonoid classes, and total flavonoids consumed on Day 1 (flav_dr1tot_1718.sas7bdat) and Day 2 (flav_dr2tot_1718.sas7bdat).
- **Documentation file** – This file you are reading (FlavonoidDB_documentation_1718.docx) explains the development of the database and SAS® data files listed above.

Please note three 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).*
2) *Proanthocyanidins (condensed tannins) are not included.*
3) *Theaflavins and thearubigins (derived tannins) are included.*

All these factors will affect how flavonoid intake estimates generated using the Flavonoid Database compare to other published estimates. For more information about the specific flavonoids and their forms, please refer to table 1 (page 6) and text on pages 6 and 7.

THE FLAVONOID DATABASE

What is the Flavonoid Database?

- Special database of flavonoid values for all foods/beverages in the FNDDS 2017-2018, which corresponds to dietary intake data from WWEIA, NHANES 2017-2018.
- Provides the amounts of 29 flavonoids in 6 flavonoid classes (Table 1) present in 100 grams of each food/beverage. Most (24) of the individual flavonoids included in the database are monomers, the 4 theaflavins are dimers, and the thearubigins are polymers. Catechins, a subclass of flavan-3ols, is comprised exclusively of monomers.

Table 1 - Flavonoids in the Flavonoid Database

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

- Based on the USDA's Expanded Flavonoid Database for the Assessment of Dietary Intakes 1.1 *(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.
- Neither FDB-EXP nor the Flavonoid Database includes estimates of the proanthocyanidin content of foods. They are excluded because sufficient data are not available for the full range of survey foods/beverages.
- The Flavonoid Database was applied to WWEIA, NHANES 2017-2018 dietary data to produce four Flavonoid Intake Data Files, which are described in more detail beginning on page 20.

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. Flavonoid composition data was provided by the USDA Nutrient Data Laboratory. (The Nutrient Data Laboratory was consolidated with the USDA Food Composition and Methods Development Laboratory in 2019 to establish the USDA Methods and Application of Food Composition 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.

Need for and uses of the Flavonoid Database

Flavonoids are polyphenolic compounds that occur naturally in plants. They exhibit multiple biologic activities that appear to confer health benefits *(4-6)*. Consumption of flavonoids has been shown to be inversely related to incidence of numerous noncommunicable diseases, including cardiovascular disease *(7,8),* cancer *(9,10),* diabetes *(11,12),* and neurocognitive disorders (*13,14).*

To facilitate research concerning these bioactive compounds, FSRG created a database that can be used to estimate complete dietary flavonoid intakes in the United States. This current version provides flavonoid values for all 7000+ foods/beverages in the FNDDS 2017-2018, the database used in coding dietary intake data and calculating nutrient intakes from WWEIA, NHANES 2017-2018. The Flavonoid Database 2017-2018 makes it possible to generate timely, nationally representative estimates of flavonoid intakes by people of all ages in the United States. The ability to link flavonoid intakes from WWEIA with other data that are included in NHANES can advance research on linkages between flavonoid intakes and health. However, the utility of the Flavonoid Database is not limited to NHANES. It may also be applied in any other studies that use FNDDS to analyze dietary intake data.

Previous Flavonoid Database releases by FSRG

Two earlier versions of the Flavonoid Database have been publicly released. They are:

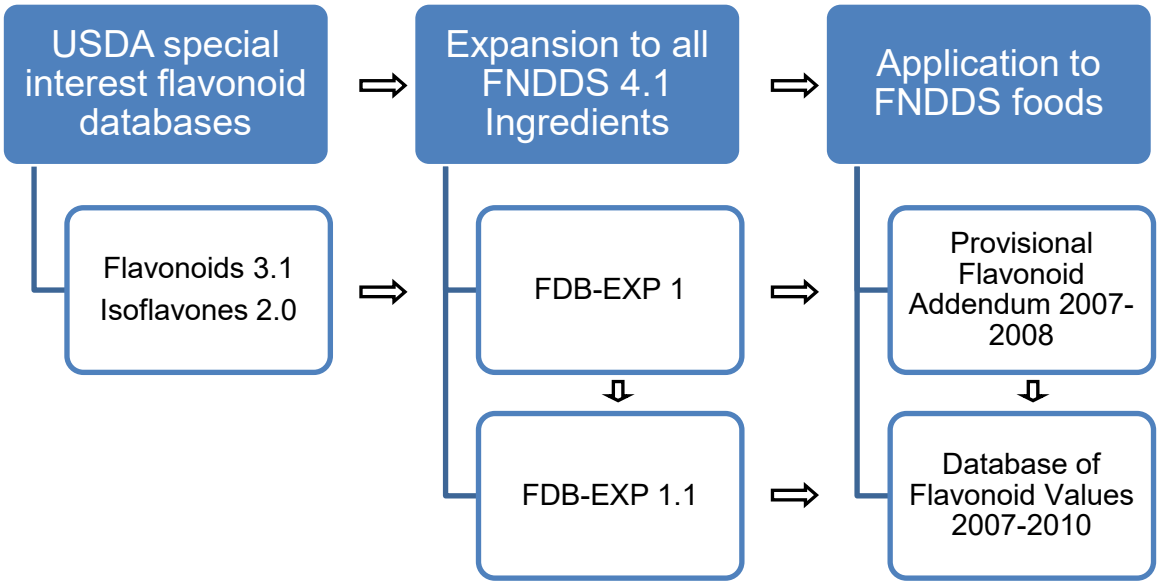
- Provisional Flavonoid Addendum to the USDA Food and Nutrient Database for Dietary Studies, 4.1 *(15)*; and
- Database of Flavonoid Values for USDA Survey Food Codes 2007-2010 *(16)*

To permit estimation of the flavonoid content of FNDDS foods, the Nutrient Data Laboratory updated and expanded two of their special interest databases, the USDA Database for the Flavonoid Content of Selected Foods Release 3.1 *(3)* and the USDA Database for the Isoflavone Content of Selected Foods Release 2.0 *(17)* to create the FDB-EXP *(18)*. FDB-EXP provides 29 flavonoid values for all ingredients (~2900 in total) that were used in FNDDS 4.1, the version used in coding dietary intake data and calculating nutrient intakes from WWEIA, NHANES 2007-2008. Application of the FDB-EXP to the FNDDS 4.1 produced the original version of the Flavonoid Database, the Provisional Flavonoid Addendum to the USDA Food and Nutrient Database for Dietary Studies, 4.1, which was released in 2015 (*15*).

The Provisional Flavonoid Addendum was expanded to permit estimation of flavonoid content for food codes added to FNDDS 5.0 (n = 99), the version corresponding to the 2009-2010 WWEIA, NHANES dietary data collection. Estimates in the resulting product, the Database of Flavonoid Values for USDA Survey Food Codes 2007-2010 (*16*), used FDB-EXP release 1.1 *(3)* as the basis for flavonoid composition.

A summary of the development of these prior releases of the Flavonoid Database is provided in Figure 1.

Figure 1. Development of Provisional Flavonoid Addendum and Database of Flavonoid Values 2007-2010



What steps were taken to update the Flavonoid Database?

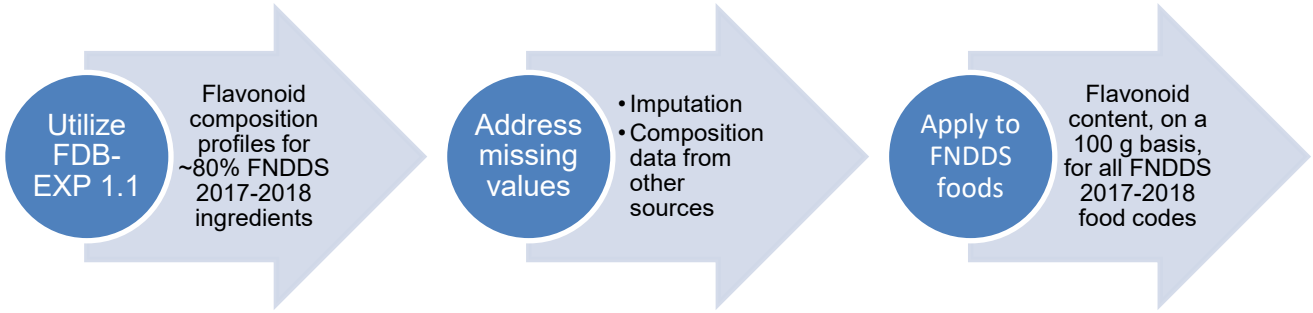
For every biannual WWEIA, NHANES survey cycle, FNDDS is updated to reflect the current marketplace of foods and beverages *(19).* For that reason, new food codes are added and outdated codes are discontinued. Between FNDDS 5.0, the version applicable to the Flavonoid Database 2007-2010, and FNDDS 2017-2018, 3,540 new food codes were added and 3,710 codes were discontinued in FNDDS *(1*).

Ingredients that were not used in previous FNDDS releases were required to develop recipes for new food codes and to revise recipes for many existing ones. For the first time with the 2017-2018 release, USDA's new integrated data system, FoodData Central (FDC) *(20)*, provided the nutrient values for FNDDS ingredients. However, FDC does not include flavonoid values for these items.

As in the 2007-2010 Flavonoid Database, FDB-EXP 1.1 served as the basis for the flavonoid composition data included in the Flavonoid Database 2017-2018. However, because of the updates conducted between survey cycles, this most recently released version of FDB-EXP only includes flavonoid profiles for 1,789 of the 2,332 unique ingredients used in FNDDS 2017-2018. These ingredients were used in FNDDS 4.1 recipes and have been retained in the FNDDS 2017-2018. Flavonoid profiles for the remaining ingredients were assigned via imputation or obtained from the scientific literature. Imputation was completed following the same philosophy as that applied to develop the FDB-EXP (see Table 2 in the FDB-EXP Release 1.1 documentation; *3)*. Taking these steps resulted in complete flavonoid profiles for every ingredient used in FNDDS 2017-2018 food code recipes.

Figure 2 provides a summary of the steps taken to update the Flavonoid Database to correspond to FNDDS 2017-2018.

Figure 2. Steps to update Flavonoid Database to reflect FNDDS 2017-2018 foods



The databases integral to the development of the Flavonoid Database 2017-2018 and some selected attributes of those databases are outlined in table 2.

Table 2 – Selected attributes of USDA databases related to the Database of Flavonoid Values for USDA Food Codes 2017-2018

Database title and version	*Release date*	*Corresponding dietary data*	*Basis for nutrient/ flavonoid data*	*Number of foods*	*Number of flavonoids*	
Flavonoid databases						
USDA Database for the Isoflavone Content of Selected Foods Release 2.0 ***(17)***	2008	–	Compilation of analytic data (mostly published data)	557	3	
USDA Database for the Flavonoid Content of Selected Foods Release 3.1 ***(3)***	2014	–	Compilation of analytic data (mostly published data)	506	26	
USDA Expanded Flavonoid Database for the Assessment of Dietary Intakes (FDB-EXP) Release 1.1 ***(3)***[1]	2015	–	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	
Flavonoid Database for USDA Survey Foods and Beverages 2017-2018	2022	WWEIA, NHANES 2017-2018	FDB-EXP release 1.1	7,083	29	
Other databases						
USDA FoodData Central ***(20)***	Downloaded Oct 31, 2019	-	Compilation of multiple data types	2,323 Standard Reference Legacy and Foundation Foods used in FNDDS 2017-2018	0	
Food and Nutrient Database for Dietary Studies (FNDDS) 2017-2018 ***(1)***	2020	WWEIA, NHANES 2017-2018	FoodData Central	7,083	0	

[1] Per the FDB-EXP 1.1 documentation *(3)*, flavonoid values reflect updated estimates of the delphinidin content of bananas as presented in the USDA Database for the Flavonoid Content of Selected Foods, Release 3.2 *(21)* and the isoflavone content for eggs and chickpeas in the USDA Database for the Isoflavone Content of Selected Foods, Release 2.1 *(22)*.

How can I obtain the Flavonoid Database?

You can download this database from the FSRG website *(23)*. It is available in 2 formats – 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 FNDDS documentation *(1).* Nutrient values for FNDDS 2017-2018 are based on composition data available in FoodData Central *(20)*. Data for about 2,300 items in FDC were used as recipe ingredients to determine the nutrient values for the over 7,000 foods/beverages in the FNDDS 2017-2018. For about two-thirds of the food codes in FNDDS, nutrient profiles were calculated using more than one FDC item. The specific items that were used to generate nutrient values for each survey food code in FNDDS, and their proportions, are identified in the FNDDSIngred file *(1)*.

In most cases, the same ingredients that had been used to create the FNDDS nutrient values were used to create the Flavonoid Database values. However, there were some differences.

Sometimes the set of recipe ingredients providing the documentation for the 65 nutrients/components for a food code in FNDDS was not the best match for calculating flavonoid values. To assure more representative flavonoid values, it was necessary to modify some existing FNDDS recipes. In other cases, recipe ingredients 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.

Minor ingredients: "5-percent rule" and exceptions

When the USDA Nutrient Data Laboratory calculated flavonoid values for items in 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. Similarly, for foods in the Flavonoid Database that were based on a combination of multiple FDB-EXP items, the same "5-percent rule" and the same exceptions (with some additions, as outlined in table 3) were applied 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.

- 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” (i.e., listed in the FNDDSIngred file) for these food codes.

In addition to the exceptions to the 5-percent rule that were made in the creation of the FDB-EXP, several 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 2017-2018 dietary interview and/or are common recipe ingredients used consistently in many foods in the FNDDS. Ingredients in FNDDS foods that met 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

	Relevant flavonoid(s)		
Ingredient	***Class***	***Subclass***	***Name***
Cocoa/chocolate	Flavan-3-ols		(-)-Epicatechin (+)-Catechin
Tea	Flavan-3-ols	Catechins	(-)-Epicatechin (-)-Epicatechin 3-gallate (-)-Epigallocatechin (-)-Epigallocatechin 3-gallate (+)-Catechin (+)-Gallocatechin
			Theaflavin Theaflavin-3,3'-digallate Theaflavin-3'-gallate Theaflavin-3-gallate Thearubigens
	Flavonols		Kaempferol Myricetin Quercetin
Soy-based products	Isoflavones		Daidzein Genistein Glycitein
Onions	Flavonols		Isorhamnetin Quercetin
Berries	Anthocyanidins		Cyanidin Delphinidin Malvidin Pelargonidin Peonidin Petunidin
	Flavonols		Myricetin

Isoflavone considerations

The predominant source of isoflavones is soy-based foods/beverages *(17),* for example, soy milk, soy-based protein powders, and tofu. For items in which soy was a principal ingredient, the isoflavone values that were present in the FDB-EXP were retained.

Most of the remainder of isoflavone intake comes 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. However, there were a few exceptions. Isoflavone values were retained for doughnuts since nearly all contain soy-based functional ingredients *(24)*. 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 regions[1]. The effect of omitting eggs from calculation of isoflavone intakes is likely to be negligible (total isoflavone content of whole raw egg was estimated to be 0.04 mg/100 g), though it does affect estimates of the percentage of individuals with zero intake of isoflavones.

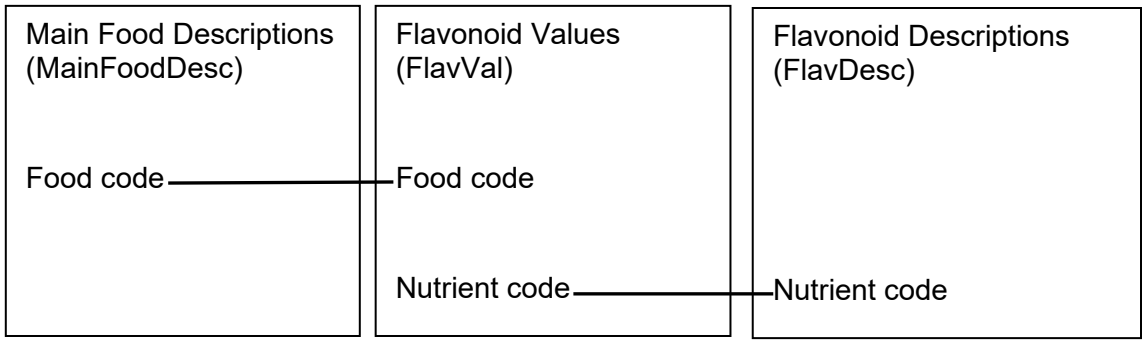
Retention factors for cooked foods

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 flavan-3-ols, flavanones, flavones, and flavanols and a loss of 50% was applied 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.

[1] See references 31 and 76a in the documentation for the USDA Database for the Isoflavone Content of Selected Foods, Release 2.1 *(22)*.

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 7,083 food codes in all. The format of the Main Descriptions file is provided on page 16.

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 6) and 1 for each of the 8 totals/subtotals, namely, total flavonoids (the sum of all 6 classes), total anthocyanidins, total catechins, total flavan-3-ols, total flavanones, total flavones, total flavonols, and total isoflavones. There are 262,071 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 17.

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 18.

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 (7,083 records in all).

Table 4 - Format of Main Food Descriptions file

Field Name	*Field Type*	*Description*
Food code‡	N*	A unique 8-digit number assigned to a particular main food description.
Start date	D (MM/DD/YYYY)	For the Flavonoid Database, all start and end dates are the same (1/1/2017 and 12/31/2018, respectively). They correspond to the time period for WWEIA, NHANES 2017-2018.
End date	D (MM/DD/YYYY)	
Main food description	A	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.

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

N = numeric field.

*Indexed field (holds values by which the file is ordered).

A = alphanumeric field.

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 262,071 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*	A unique 8-digit number assigned to a particular main food description.
Nutrient code‡	N*	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 (1/1/2017 and 12/31/2018, respectively). They correspond to the time period for WWEIA, NHANES 2017-2018.
End date	D (MM/DD/YYYY)	
Nutrient value	N	Amount of nutrient (flavonoid) in 100 grams edible portion of the food; follows conventions in FDB-EXP *(3).* Estimates are presented to two decimal places.

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

N = numeric field.

*Indexed field (holds values by which the file is ordered).

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*	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	Name of the flavonoid.
Flavonoid class	A	The class of flavonoids to which the individual flavonoid belongs.
Tagname	A	The nutrient or food component name or "tag" assigned by INFOODS, the International Network of Food Data Systems, for international interchange of nutrient data *(25)*. 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	The measurement unit in which values for the nutrient are expressed.
Decimals	N	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.

*Indexed field (holds values by which the file is ordered).

A = alphanumeric field.

Limitations of the Flavonoid Database

- Estimates of the proanthocyanidin (condensed tannins) content of foods are not included in the Flavonoid Database. FDB-EXP 1.1, which provides the basis for flavonoid content of FNDDS foods, does not include profiles for these compounds.
- Many values in the FDB-EXP are assumed to be zero because they are absent in flavonoids or only contain trace amounts; for example, milk is not expected to contain flavonoids in clinically relevant amounts, since it is exclusively of animal origin. Similarly, whereas tomatoes do contain flavanones and flavonols, they would not be expected to contain isoflavones since they do not contain soy. Among the flavonoid values that are not assumed to be zero, only ~11.4% are analytical values. However, the foods/beverages that do have analytical values account for a large proportion of flavonoid intake overall. The remainder of the values in the FDB-EXP that were not assumed to be zero were imputed based on data for similar foods. Assignment of flavonoid values to foods is explained in detail in the FDB-EXP documentation *(3)*.
- The Flavonoid Database contains profiles for food codes in FNDDS 2017-2018. If another version of FNDDS is used to code dietary intakes, there will be food codes with missing flavonoid profiles. The previously released version, the Database of Flavonoid Values for USDA Survey Food Codes 2007-2010 *(16),* may be used to estimate flavonoid intakes in any study that applied FNDDS 4.1 and/or 5.0.
- 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 2017-2018. Some underlying assumptions that are correct for 2017-2018 may not be correct for other time periods.
- As described in the section "Isoflavone considerations," isoflavone values were set to zero when the FDB-EXP contained non-zero isoflavone values for a given SR code, but isoflavones in such an item would be provided by a functional ingredient that 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 *(26)*. 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 *(23)* to dietary intake data from WWEIA, NHANES 2017-2018 *(2)*.
- Permit calculation of nationally representative estimates of flavonoid intakes by people of all ages in the United States in 2017-2018.
- 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. Look for the tab "2017-2018 Documentation and Data Files" *(23)*. 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 2017-2018 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 independently 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).

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) 2017-2018

Type of data	*Name (description)of Flavonoid Intake Data File*	*Key identifier(s)*	*Number of records*	*Name (description) of corresponding WWEIA, NHANES files*
Individual foods	*flav_dr1iff_1718.sas7bdat* *(Day 1 Individual Foods Flavonoid File)*	SEQN, DR1ILINE	112,683	DR1IFF_J.xpt (Day 1 Individual Foods File)
	flav_dr2iff_1718.sas7bdat *(Day 2 Individual Foods Flavonoid File)*	SEQN, DR2ILINE	93,500	DR2IFF_J.xpt (Day 2 Individual Foods File)
Total flavonoids	*flav_dr1tot_1718.sas7bdat* *(Day 1 Total Flavonoid File)*	SEQN	8,704	DR1TOT_J.xpt (Day 1 Total Nutrient File)
	flav_dr2tot_1718.sas7bdat *(Day 2 Total Flavonoid File)*	SEQN	8,704	DR2TOT_J.xpt (Day 2 Total Nutrient File)

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 2017-2018 dietary intake file and contains records for the same individuals and food reports. Documentation for the WWEIA, NHANES 2017-2018 survey data files may be found at http://wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?Component=Dietary&CycleBeginYear=2017

.

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

Day 1 variable name	*Day 2 variable name*	*Description[1]*
seqn	**seqn**	Respondent sequence 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]
dr1i_fl759	**dr2i_fl759**	759 Hesperetin (mg) [Flavanones]
dr1i_fl762	**dr2i_fl762**	762 Naringenin (mg) [Flavanones]

Day 1 variable name	*Day 2 variable name*	*Description[1]*
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)

[1]The “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)

Day 1 variable name	*Day 2 variable name*	*Description*[1]
seqn	**seqn**	Respondent sequence number
dr1drstz	**dr2drstz**	Dietary recall status[2]
dr1t_fl710	**dr2t_fl710**	710 Daidzein (mg) [Isoflavones]
dr1t_fl711	**dr2t_fl711**	711 Genistein (mg) [Isoflavones]
dr1t_fl712	**dr2t_fl712**	712 Glycitein (mg) [Isoflavones]
dr1t_fl731	**dr2t_fl731**	731 Cyanidin (mg) [Anthocyanidins]
dr1t_fl740	**dr2t_fl740**	740 Petunidin (mg) [Anthocyanidins]
dr1t_fl741	**dr2t_fl741**	741 Delphinidin (mg) [Anthocyanidins]
dr1t_fl742	**dr2t_fl742**	742 Malvidin (mg) [Anthocyanidins]
dr1t_fl743	**dr2t_fl743**	743 Pelargonidin (mg) [Anthocyanidins]
dr1t_fl745	**dr2t_fl745**	745 Peonidin (mg) [Anthocyanidins]
dr1t_fl749	**dr2t_fl749**	749 (+)-Catechin (mg) [Flavan-3-ols]
dr1t_fl750	**dr2t_fl750**	750 (-)-Epigallocatechin (mg) [Flavan-3-ols]
dr1t_fl751	**dr2t_fl751**	751 (-)-Epicatechin (mg) [Flavan-3-ols]
dr1t_fl752	**dr2t_fl752**	752 (-)-Epicatechin 3-gallate (mg) [Flavan-3-ols]
dr1t_fl753	**dr2t_fl753**	753 (-)-Epigallocatechin 3-gallate (mg) [Flavan-3-ols]
dr1t_fl755	**dr2t_fl755**	755 Theaflavin (mg) [Flavan-3-ols]
dr1t_fl756	**dr2t_fl756**	756 Thearubigins (mg) [Flavan-3-ols]
dr1t_fl758	**dr2t_fl758**	758 Eriodictyol (mg) [Flavanones]
dr1t_fl759	**dr2t_fl759**	759 Hesperetin (mg) [Flavanones]
dr1t_fl762	**dr2t_fl762**	762 Naringenin (mg) [Flavanones]
dr1t_fl770	**dr2t_fl770**	770 Apigenin (mg) [Flavones]
dr1t_fl773	**dr2t_fl773**	773 Luteolin (mg) [Flavones]
dr1t_fl785	**dr2t_fl785**	785 Isorhamnetin (mg) [Flavonols]
dr1t_fl786	**dr2t_fl786**	786 Kaempferol (mg) [Flavonols]
dr1t_fl788	**dr2t_fl788**	788 Myricetin (mg) [Flavonols]

Day 1 variable name	*Day 2 variable name*	*Description*[1]
dr1t_fl789	**dr2t_fl789**	789 Quercetin (mg) [Flavonols]
dr1t_fl791	**dr2t_fl791**	791 Theaflavin-3,3'-digallate (mg) [Flavan-3-ols]
dr1t_fl792	**dr2t_fl792**	792 Theaflavin-3'-gallate (mg) [Flavan-3-ols]
dr1t_fl793	**dr2t_fl793**	793 Theaflavin-3-gallate (mg) [Flavan-3-ols]
dr1t_fl794	**dr2t_fl794**	794 (+)-Gallocatechin (mg) [Flavan-3-ols]
dr1t_fl_total	**dr2t_fl_total**	7000 Flavonoid totals: Sum of all 29 individual flavonoids (mg)
dr1t_fl_antho	**dr2t_fl_antho**	7100 Flavonoid totals: Anthocyanidins (mg)
dr1t_fl_catechin	**dr2t_fl_catechin**	7200 Flavonoid subtotal: Catechins (mg) [Flavan-3-ols]
dr1t_fl_3_ols	**dr2t_fl_3_ols**	7300 Flavonoid totals: Flavan-3-ols (mg)
dr1t_fl_nones	**dr2t_fl_nones**	7400 Flavonoid totals: Flavanones (mg)
dr1t_fl_ones	**dr2t_fl_ones**	7500 Flavonoid totals: Flavones (mg)
dr1t_fl_ols	**dr2t_fl_ols**	7600 Flavonoid totals: Flavonols (mg)
dr1t_fl_iso	**dr2t_fl_iso**	7700 Flavonoid totals: Isoflavones (mg)

[1]The "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.

[2]Identical to the variable with the same name in the NHANES Dietary Interview – Total Nutrient Intakes, First Day and Second Day files (DR1TOT_J and DR2TOT_J, respectively) *(2).*

LITERATURE CITED

1. U.S. Department of Agriculture, Food Surveys Research Group [Internet]. *FNDDS Documentation and Databases* [modified 2021 Jan 7; cited 2022 May 13]. 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 2021 Jan 29; cited 2022 May 13]. Available from: http://www.ars.usda.gov/Services/docs.htm?docid=18354.

3. U.S. Department of Agriculture, Methods and Application of Food Composition Laboratory [Internet]. USDA Special Interest Databases on Flavonoids [includes USDA Database for the Flavonoid Content of Selected Foods Release 3.1 and 3.3, and USDA's Expanded Flavonoid Database for the Assessment of Dietary Intakes Release 1.1); updated 2021 Mar 31; cited 2022 May 13]. Available from: http://www.ars.usda.gov/Services/docs.htm?docid=24953.

4. Santhakumar AB, Bulmer AC, Singh I. A review of the mechanisms and effectiveness of dietary polyphenols in reducing oxidative stress and thrombotic risk. *J Hum Nutr Diet.* 2014;27(1):1-21. doi:10.1111/jhn.12177

5. Chen L, Teng H, Jia Z, et al. Intracellular signaling pathways of inflammation modulated by dietary flavonoids: The most recent evidence. *Crit Rev Food Sci Nutr.* 2018;58(17):2908-2924. doi:10.1080/10408398.2017.1345853

6. Kumar S, Pandey AK. Chemistry and biological activities of flavonoids: an overview. *ScientificWorldJournal.* 2013;2013:162750. doi:10.1155/2013/162750

7. Mendonça RD, Carvalho NC, Martin-Moreno JM, et al. Total polyphenol intake, polyphenol subtypes and incidence of cardiovascular disease: The SUN cohort study. *Nutr Metab Cardiovasc Dis.* 2019;29(1):69-78. doi:10.1016/j.numecd.2018.09.012

8. Goetz ME, Judd Se, Safford MM, Hartman TJ, McClellan WM, Vaccarino V. Dietary flavonoid intake and incident coronary heart disease: the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study. *Am J Clin Nutr.* 2016;104(5):1236-1244. doi:10.3945/ajcn.115.129452

9. Rossi M, Bosetti C, Negri E, Lagiou P, La Vecchia C. Flavonoids, proanthocyanidins, and cancer risk: a network of case-control studies from Italy. *Nutr Cancer*. 2010;62(7):871-877. doi:10.1080/01635581.2010.509534

10. Tang NP, Zhou B, Wang B, Yu RB, Ma J. Flavonoids intake and risk of lung cancer: a meta-analysis. *Jpn J Clin Oncol.* 2009;39(6):352-359. doi:10.1093/jjco/hyp028

11. Xu H, Luo J, Huang J, Wen Q. Flavonoids intake and risk of type 2 diabetes mellitus: A meta-analysis of prospective cohort studies. *Medicine (Baltimore).* 2018;97(19):e0686. doi:10.1097/MD.0000000000010686.

12. Grosso G, Stepanik U, Micek A, et al. Dietary polyphenol intake and risk of type 2 diabetes in the Polish arm of the Health, Alcohol and Psychosocial factors in Eastern Europe (HAPIEE) study. *Br J Nutr.* 2017;118(1):60-68. doi:10.1017/S0007114517001805

13. Shishtar E, Rogers GT, Blumberg JB, Au R, Jacques PF. Long-term dietary flavonoid intake and risk of Alzheimer disease and related dementias in the Framingham Offspring Cohort. *Am J Clin Nutr*. 2020;112(2):343-353. doi:10.1093/ajcn/nqaa079

14. Holland TM, Agarwal P, Wang Y, et al. Dietary flavonols and risk of Alzheimer dementia. *Neurology.* 2020;94(16):e1749-e1756. doi:10.1212/WNL.0000000000008981.

15. 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 2022 May 17]. Available from: http://www.ars.usda.gov/SP2UserFiles/Place/12355000/pdf/fndds/FlavonoidDB_doc.pdf.

16. Sebastian RS, Wilkinson Enns C, Goldman JD, Steinfeldt LC, Martin CL, Moshfegh AJ. *Flavonoid Values for USDA Survey Foods and Beverages 2007-2010: Database of Flavonoid Values for USDA Food Codes and Flavonoid Intake Data Files from What We Eat in America (WWEIA), National Health and Nutrition Examination Survey (NHANES) 2007-2010* [Internet]. Beltsville, MD: U.S. Department of Agriculture, Agricultural Research Service, Food Surveys Research Group; 2016 [cited 2022 May 17]. Available from: https://www.ars.usda.gov/ARSUserFiles/80400530/pdf/fndds/FlavonoidDB_documentation_0710.pdf

17. Bhagwat S, Haytowitz DB, Holden, JM. *USDA Database for the Isoflavone Content of Selected Foods, Release 2.0* [Internet]. U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory 2008 [cited 2022 May 17]. Available from: https://www.ars.usda.gov/ARSUserFiles/80400525/Data/isoflav/Isoflav_R2.pdf

18. Bhagwat S, Haytowitz DB, Wasswa-Kintu S. *USDA's Expanded Flavonoid Database for the Assessment of Dietary Intakes* [Internet]. U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory 2014 [cited 2022 May 20]. Available from: https://www.ars.usda.gov/ARSUserFiles/80400525/Data/Flav/FDB-EXP.pdf

19. U.S. Department of Agriculture, Food Surveys Research Group [Internet]. *FNDDS FAQs* [modified 2021 Jan 7; cited 2022 May 17]. Available from:. https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds/

20. U.S. Department of Agriculture, Agricultural Research Service [Internet]. *FoodData Central* [modified 2022 Apr 18; cited 2022 May 31] Available from: https://fdc.nal.usda.gov

21. Bhagwat S, Haytowitz DB. *USDA Database for the Flavonoid Content of Selected Foods, Release 3.2* [Internet]. Beltsville, MD: U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory; 2015 [cited 2022 May 17].

Available from: https://data.nal.usda.gov/dataset/usda-database-flavonoid-content-selected-foods-release-32-november-2015

22. U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. *USDA Database for the Isoflavone Content of Selected Foods, Release 2.1* [Internet]. Beltsville, MD: U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory; 2015 [cited 2022 May 17]. Available from: https://data.nal.usda.gov/dataset/usda-database-isoflavone-content-selected-foods-release-21-november-2015

23. U.S. Department of Agriculture, Agricultural Research Service, Food Surveys Research Group [Internet]. *Flavonoid Values for USDA Survey Foods and Beverages 2017-2018 Documentation and Data Files* [cited 2022 July 20]. Available from: https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds-flavonoid-database/.

24. 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.

25. Food and Agriculture Organization of the United Nations [Internet]. *International Network of Food Data Systems (INFOODS): Tagnames for Food Components* [updated 2017 Mar 1; cited 2022 May 25]. Available from: http://www.fao.org/infoods/infoods/standards-guidelines/food-component-identifiers-tagnames/en/.

26. 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.