



# Dietary Intake and Sources of Flavonoids by Adults in the U.S.

## What We Eat in America, NHANES 2017-2018

Food Surveys Research Group  
Dietary Data Brief No. 49  
October 2023

Rhonda S. Sebastian, MA; Joseph D. Goldman, MA  
and Alanna J. Moshfegh, MS, RD

### Highlights

- ▶ On any given day, 99% of adults consume foods and/or beverages containing flavonoids, albeit in small amounts for most. Intake does not vary by gender.
- ▶ The median flavonoid intake of non-Hispanic Asian adults is higher than that of all other race/ethnic groups.
- ▶ Adults in the highest category of family income have higher median flavonoid intake relative to those with lower incomes.
- ▶ Tea accounts for 91% of flavan-3-ol intake and 75% of total flavonoid intake. It is also among the top sources of flavanols and flavones.
- ▶ Berries and grapes - eaten alone, as juices, and in mixtures - are the top food contributors to anthocyanidin intake.
- ▶ Oranges and orange juice account for over two-thirds of flavanone intake.
- ▶ Soy-containing nutritional products are the primary source of isoflavone intake.

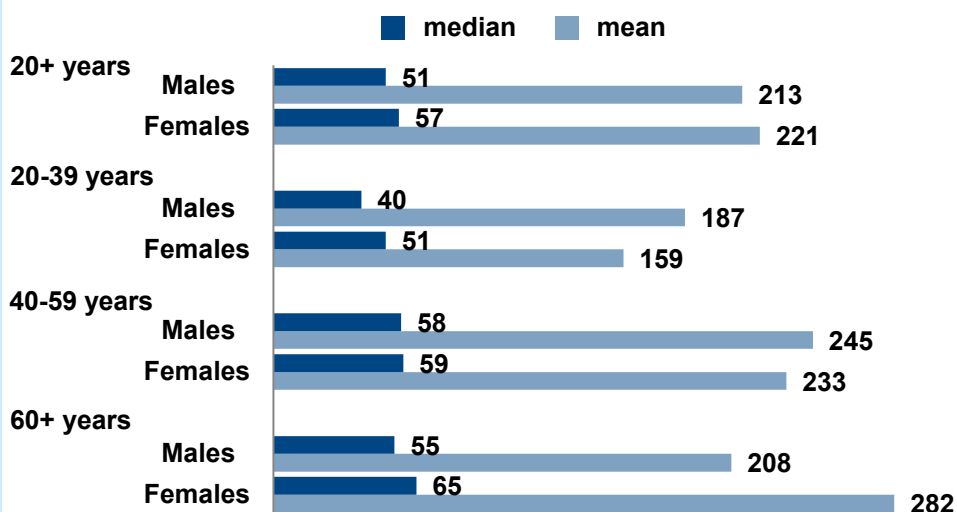
National dietary guidance encourages intake of fruits and vegetables in part due to their potential health-promoting effects (1). Flavonoids, a large family of compounds made by plants, may play a role in conferring these benefits. Studies have found that intake of flavonoids is related to lower incidence of many chronic diseases, including cardiovascular disease, diabetes, and cancer (2-5). Flavonoids fall into six distinct classes based on their chemical structure: anthocyanidins, flavan-3-ols, flavanones, flavones, flavonols, and isoflavones (6). This report provides intake estimates and top food group contributors to flavonoids among adults 20 years of age and older using dietary data collected in What We Eat in America (WWEIA), NHANES 2017-2018.

### Who consumes flavonoids, and does intake vary by gender?

Overall, nearly all (99%) of adults consume foods and/or beverages containing flavonoids on any given day. For most, intakes are very low (*see Statistical notes on page 7*).

Mean and median flavonoid intakes among males and females 20 years of age and older are shown in Figure 1 (*see definition of "median" on page 6*). Within each age group, the median intake estimates do not vary by gender ( $p > 0.001$ ).

**Figure 1. Total flavonoid intake (mg) among U.S. adults 20+ years, by sex and age, 2017-2018**



SOURCE: WWEIA, NHANES 2017-2018, day 1, adults 20 years of age and older.



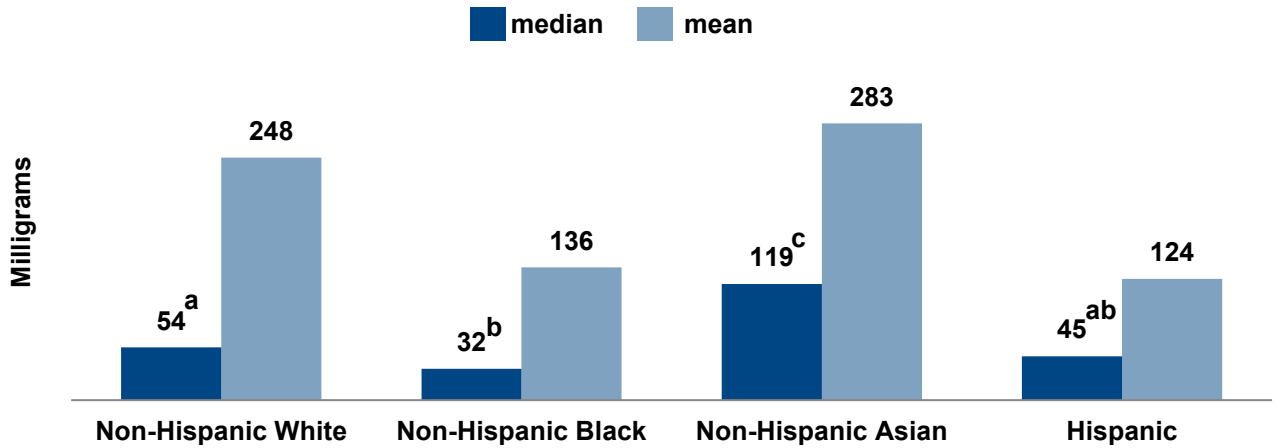
U.S. DEPARTMENT OF AGRICULTURE  
Agricultural Research Service  
Beltsville Human Nutrition Research Center  
Food Surveys Research Group

[www.ars.usda.gov/nea/bhnrc/fsrg](http://www.ars.usda.gov/nea/bhnrc/fsrg)

Does flavonoid intake vary by race/ethnicity or family income?

Total flavonoid intakes among adults by race/ethnic group are presented in Figure 2. The median intake of non-Hispanic Black adults is lower than that of non-Hispanic White adults, and the median intake of non-Hispanic Asian adults is higher than that of all other groups ( $p < 0.001$ ).

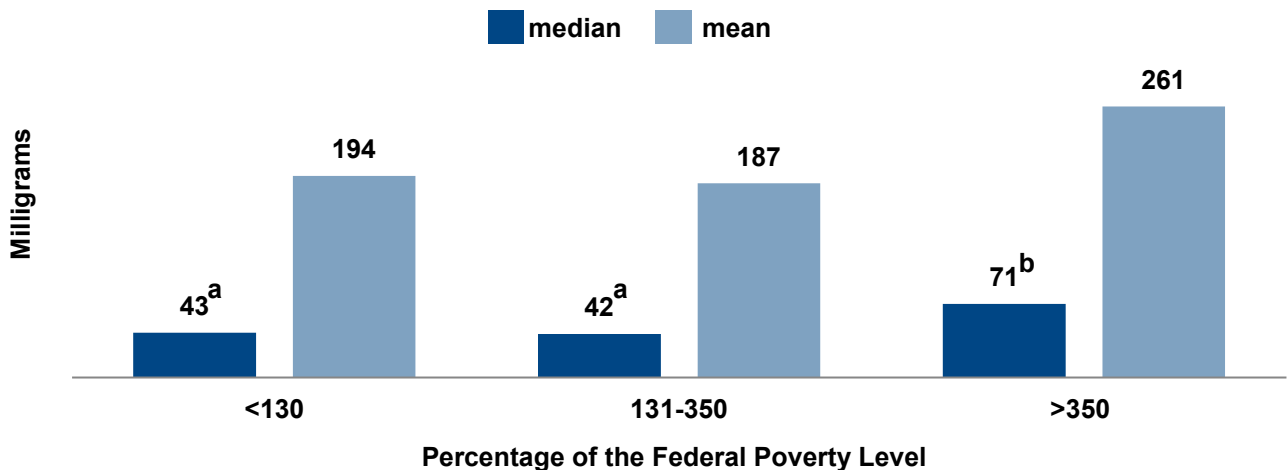
Figure 2. Flavonoid intake (mg) among U.S. adults 20+ years by race/ethnicity, 2017-2018



<sup>a,b,c</sup> Medians with different letters were significantly different from one another ( $p < 0.001$ ; See Statistical notes on page 7).  
 SOURCE: WWEIA, NHANES 2017-2018, day 1, adults 20 years of age and older.

As shown in Figure 3, median intake of flavonoids is greater among adults in the highest income category relative to those in either the lowest or the middle income category (*see definition of family income as a percentage of poverty level on page 6*)

Figure 3. Flavonoid intake (mg) among U.S. adults 20+ years by family income, 2017-2018



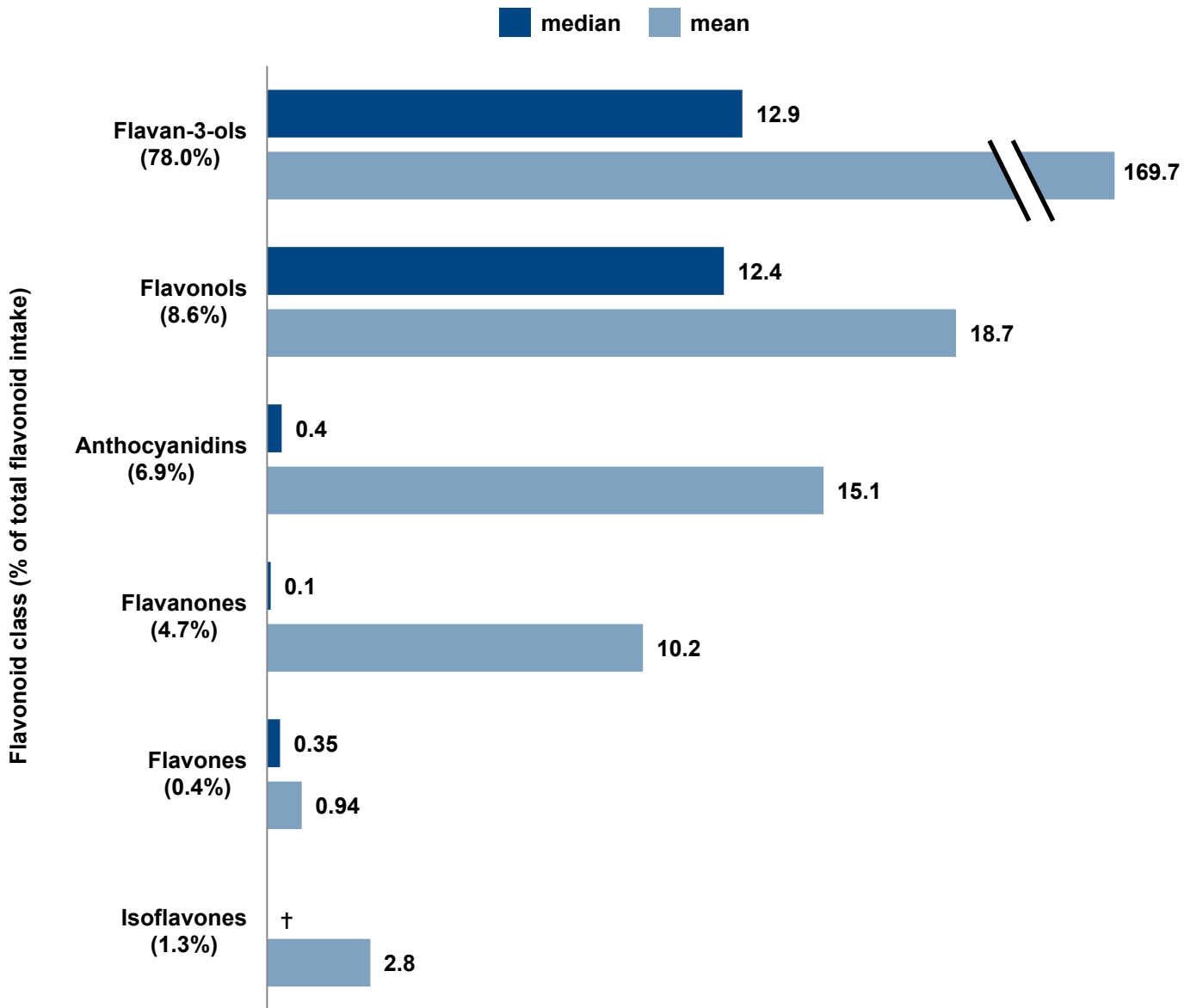
<sup>a,b</sup> Medians with different letters were significantly different from one another ( $p < 0.001$ ; See Statistical notes on page 7).  
 SOURCE: WWEIA, NHANES 2017-2018, day 1, adults 20 years of age and older.

## What is the intake of flavonoid classes among U.S. adults?

The mean and median intake of flavan-3-ols, flavonols, anthocyanidins, flavanones, flavones, and isoflavones are shown in Figure 4. Flavan-3-ols account for nearly 80% of total flavonoid intake.

Though some flavonoid classes are consumed by nearly all adults on any given day, for others, a large percentage of adults consume none at all. For example, whereas 99 percent of adults have non-zero intake of flavonols, only 45 percent consume any isoflavone-containing foods.

**Figure 4. Flavonoid class intake<sup>1</sup> (mg) among U.S. adults 20+ years, 2017-2018**



<sup>1</sup>The percentage of adults reporting each flavonoid class on the intake day are as follows: flavan-3-ols, 93%; flavonols, 99%; anthocyanidins, 63%; flavanones, 58%; flavones, 86%; isoflavones, 45%.

†More than 50% of adults consume no foods containing isoflavones on the intake day.

SOURCE: WWEIA, NHANES 2017-2018, day 1, adults 20 years of age and older.

## What are the top contributors to total flavonoids, flavan-3-ols, flavonols, and anthocyanidins?

As shown in Table 1, black and green tea provide 91% of flavan-3-ol intake. Because this class comprises the majority of flavonoid intake (*see Figure 4 on page 3*), tea is the top contributor to flavonoids among U.S. adults, accounting for 75% of total intake overall (54% from black, 20% from green). Table 1 shows that tea also contributes approximately one-third of daily intake of flavonols. Vegetables, particularly onions and dark greens, are high in flavonol content as well. These foods are common ingredients in mixed dishes. Berries – eaten alone or as a component of foods such as nuts and seed-based trail mixes and flavored milk and other dairy drinks- account for over half of anthocyanidin intake. Grapes and grape-based products, including juice and red wine, are the other top dietary sources of this class.

**Table 1. Food and beverage groups<sup>1</sup> that are top contributors (account for 5% or more of total intake) of flavan-3-ols, flavonols, and anthocyanidins, adults 20+ years, 2017-2018**

Flavan-3-ols		Flavonols		Anthocyanidins	
Food Group	Contribution (%)	Food Group	Contribution (%)	Food Group	Contribution (%)
Black tea	67	Black tea	24	Blueberries	19
Green tea	24	Mixed dishes	17	Red wine (includes dessert wine)	11
		Green tea	10	Flavored milk/other dairy drinks (includes dairy-based smoothies)	9
		Dark green vegetables	7	Grapes	9
				100% noncitrus fruit juice (not apple)	7
				Cranberries	7
				Strawberries	6
				Nuts and seeds	5
				Blackberries, raspberries	5
<b>Total</b>	<b>91</b>	<b>Total</b>	<b>58</b>	<b>Total</b>	<b>78</b>

<sup>1</sup>See Definition of “Food groups” on page 6.

SOURCE: WWEIA, NHANES 2017-2018, day 1, adults 20 years of age and older.

## What are the top contributors to flavanones, flavones, and isoflavones?

The main contributors to flavanones reflect the fact that this class is found exclusively in citrus fruits (Table 2). Dietary sources of flavones include vegetables, which are consumed alone or in mixed dishes. Hot peppers have high flavone content, and explain why condiments and sauces are top contributions to intake of this class. Green tea is also a notable source of flavones. Isoflavones are found exclusively in products containing soy in some form, e.g., soy protein isolate and tofu.

**Table 2. Food and beverage groups<sup>1</sup> that are top contributors (account for 5% or more of total intake) of flavanones, flavones, and isoflavones, adults 20+ years, 2017-2018**

Flavanones		Flavones		Isoflavones	
Food Group	Contribution (%)	Food Group	Contribution (%)	Food Group	Contribution (%)
Orange juice	39	Mixed dishes	22	Nutritional beverages	38
Oranges	30	Other vegetables, vegetable combinations	12	Protein and nutrition powders	19
Clementines and tangerines	6	Condiments and sauces	9	Nutrition bars	17
Grapefruit	5	Green tea	8	Processed soy products	7
		Sweet peppers	8		
		Melons	6		
		Dark green vegetables	6		
<b>Total</b>	<b>80</b>	<b>Total</b>	<b>71</b>	<b>Total</b>	<b>81</b>

<sup>1</sup>See Definition of “Food groups” on page 6.

SOURCE: WWEIA, NHANES 2017-2018, day 1, adults 20 years of age and older.

## Definitions

**Family income (as percentage of poverty level):** the ratio of family income to poverty expressed as a percentage. The Department of Health and Human Services' poverty guidelines were used as the poverty measure to calculate the ratio (7).

**Food groups:** In general, food/beverage groups listed as food sources of total flavonoids/flavonoid classes correspond to the 2017-2018 WWEIA Food Categories (*see definition and link below*). Some WWEIA categories were divided into smaller groups to underscore foods exceptionally high in a particular flavonoid class. For example, foods in the WWEIA category “Blueberries and other berries” were split into three groups- “blueberries”; “cranberries”; and “blackberries, raspberries” because berries are a top contributor to anthocyanidin intake. (Note: “Strawberries” is a separate WWEIA category.) In other cases, multiple WWEIA categories were merged to create a new group.

**Median:** The middle value within a set of data values for a given variable. Half of all values are less than the median, and half of all values are greater than the median. In a symmetric distribution, the mean and median are similar. In a right-skewed distribution, the mean can be much larger than the median.

**Percentile:** Value below which a certain percentage of the values in a data set are found, e.g., if a value of 200 is at the 75<sup>th</sup> percentile, 75 percent of the values are below 200, and 25 percent are above 200. The median is analogous to the 50<sup>th</sup> percentile for a given set of data values.

**Skewed distribution:** a set of values for a variable that when plotted form an asymmetric, or non-normal (i.e., not bell-shaped) curve. Flavonoid intake distributions exhibit a right skew, characterized by a large proportion of zero/low intake observations and a long right tail reflecting a relatively small proportion of very high intake observations.

**Total flavonoids:** Summative total of the following flavonoid classes: anthocyanidins, flavan-3-ols, flavanones, flavones, flavonols, and isoflavones. Excludes the contribution of dietary supplements.

**WWEIA Food Categories:** A scheme applied to classify each food and beverage reported in WWEIA, NHANES into one of approximately 165 mutually exclusive categories ([www.ars.usda.gov/Services/docs.htm?docid=23429](http://www.ars.usda.gov/Services/docs.htm?docid=23429)).

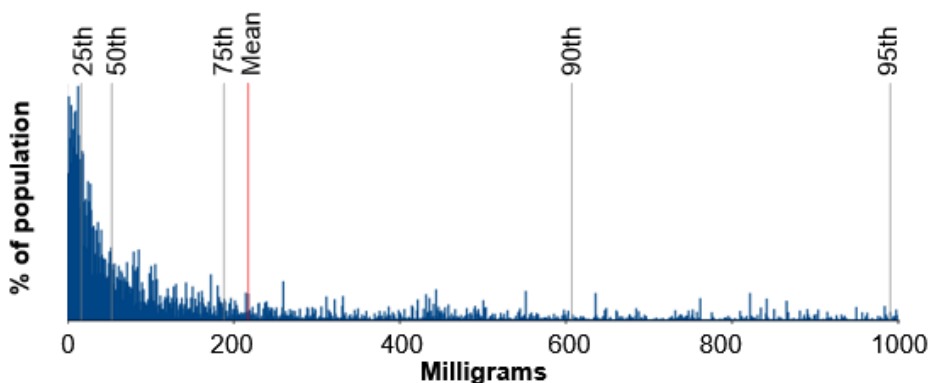
## Data source

Estimates in this data brief are based on one day of data from WWEIA, NHANES 2017-2018 (8). Day 1 dietary data were collected in person using the 5-step USDA Automated Multiple-Pass Method for the 24-hour recall (9). A total of 4,742 individuals age  $\geq 20$  years (2307 males and 2435 females) provided complete and reliable dietary intake data. In the race-specific analysis (*page 2*), non-Hispanic individuals who were multi-racial or of a racial group other than those listed ( $n = 236$ ) were excluded. Similarly, individuals who did not report family income ( $n = 558$ ) were excluded from the income-based analysis (*page 2*). Intakes of flavonoids were calculated using the 2017-2018 versions of the Database of Flavonoid Values for USDA Food Codes (10) and USDA's Food and Nutrient Database for Dietary Studies (11).

## Statistical notes

The figure below shows the intake distribution of total flavonoids among adults, and the mean, median, and selected percentiles of that distribution. (See definitions of “total flavonoids”, “median” and “percentile” on page 6). Flavonoids are highly concentrated in some plant foods, but low or absent in others. Individuals who consume foods in the former group have high intakes, while those who do not have relatively low intakes, resulting in highly skewed intake distributions. (See definition of “skewed distribution” on page 6.) Strong right-skewness as displayed here can cause means to be much larger than medians.

**Distribution<sup>1</sup> of total flavonoid intake by U.S. adults 20+ years, 2017-2018**



<sup>1</sup>Mean (red line), and selected percentiles shown. Intakes above 1000 mg/d not displayed.  
SOURCE: WWEIA, NHANES 2017-2018, day 1, adults 20 years of age and older.

Because flavonoid intake distributions did not meet all assumptions for parametric testing (i.e., data did not show a normal distribution), nonparametric testing were employed to detect differences in intake between population groups. Specifically, median intakes were compared using the quantile test described in (12).

Sample weights were applied in all analyses to produce nationally representative estimates.

## References

1. Dietary Guidelines Advisory Committee. 2020. *Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and the Secretary of Health and Human Services*. U.S. Department of Agriculture, Agricultural Research Service, Washington, DC. Available: <https://doi.org/10.52570/DGAC2020>.
2. Li T, Zhao Y, Yuan L, et al. Total dietary flavonoid intake and risk of cardiometabolic diseases: A does-response meta-analysis of prospective cohort studies [published online ahead of print, 2022 Sep 23]. *Crit Rev Food Sci Nutr*. 2022;1-13. doi:10.1080/10408398.2022.2126427.
3. Zamora-Ros R, Forouhi NG, Sharp SJ, et al. The association between dietary flavonoid and lignan intakes and incident type 2 diabetes in European populations: the EPIC-InterAct study. *Diabetes Care*. 2013;36(12):3961-3970. doi:10.2337/dc13-0877
4. Kopustinskiene DM, Jakstas V, Savickas A, Bernatoniene J. Flavonoids as Anticancer Agents. *Nutrients*. 2020;12(2):457. Published 2020 Feb 12. doi:10.3390/nu12020457
5. 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
6. Beecher, GR. Overview of dietary flavonoids: nomenclature, occurrence and intake. *J Nutr*. 2003;133(10):3248S-3254S. Doi:10.1093/jn/133.10.3248S.
7. U.S. Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation. Poverty guidelines. <https://aspe.hhs.gov/poverty-guidelines>. Accessed March 6, 2023.
8. Centers for Disease Control and Prevention, National Center for Health Statistics. *NHANES Questionnaires, Datasets, and Related Documentation*. <https://www.cdc.gov/nchs/nhanes/>. Accessed March 15, 2023.
9. USDA Food Surveys Research Group. *AMPM - USDA Automated Multiple Pass Method*. [www.ars.usda.gov/nea/bhnrc/fsrg/ampm](http://www.ars.usda.gov/nea/bhnrc/fsrg/ampm) . Accessed February 2, 2023.
10. USDA Food Surveys Research Group. *Flavonoid Database*. [www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds-flavonoid-database/](http://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/docs/fndds-flavonoid-database/) . Accessed February 2, 2023.
11. USDA Food Surveys Research Group. *FNDDS Documentation and Databases*. [www.ars.usda.gov/fsrg/fndds/download](http://www.ars.usda.gov/fsrg/fndds/download). Accessed February 2, 2023.
12. Pan Y, Caudill SP, Li R, Caldwell KL. Median and quantile tests under complex survey design using SAS and R. *Comput Methods Programs Biomed*. 2014;117(2):292-297. doi:10.1016/j.cmpb.2014.07.007.



## About the authors

Rhonda S. Sebastian, Joseph D. Goldman, and Alanna J. Moshfegh are with the Food Surveys Research Group, Beltsville Human Nutrition Research Center, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD.

## Suggested citation

Sebastian RS, Goldman JD, and Moshfegh AJ. *Dietary Intake and Sources of Flavonoids by Adults in the U.S.: What We Eat in America, NHANES 2017-2018*. Food Surveys Research Group Dietary Data Brief No. 49. October 2023.

## Copyright information

All material appearing in this report is in the public domain and may be reproduced or copied without permission. However, citation as to source is appreciated.

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 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, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

