FoodData Central

Foundation Foods

Documentation and User Guide

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Preface

The food supply, and the scientific understanding of relationships between dietary intakes and health, have evolved over the years. USDA's food composition data resources also have evolved to meet the needs of diverse users, including researchers, policymakers, academicians and educators, nutrition professionals, product developers, and others. In recent years, the rapidly escalating pace of change in the food supply and the growing variety of uses for food data have greatly enhanced the need for transparent and easily accessible information about the food component including nutrients of foods and food products. This need required a new approach to analyzing, compiling, and presenting food profile information in a scientifically rigorous way. FoodData Central is USDA's response to this need.

This integrated data system contains—in one place—five distinct types of food component, including nutrient (**component**) composition data, each with a unique purpose. Three of these data types are well-established and familiar to many users: The **National Nutrient Database for Standard Reference (SR Legacy)**, the **Food and Nutrient Database for Dietary Studies**, and the **USDA Global Branded Food Products Database.** The other two data types—**Foundation Foods** and **Experimental Foods**—provide data that may not have been previously available.

- **Foundation Foods** includes values derived from analyses for components on a diverse range of foods and ingredients as well as extensive underlying metadata. These metadata include the number of samples, sampling location, date of collection, analytical approaches used, and if appropriate, agricultural information such as genotype and production practices. The enhanced depth and transparency of Foundation Foods data can provide valuable insights into the many factors that influence variability in component profiles. The goal of Foundation Foods will be to, over time, expand the number of basic foods and ingredients and their underlying data.
- **Experimental Foods** contains foods produced, acquired, or studied under unique conditions, such as alternative management systems, experimental genotypes, or research/analytical protocols. The foods in this data type may not be commercially available to the general public or the data may expand information about the specific food. Experimental Foods are for research purposes and may not be appropriate as a reference for the consumer or for diet planning. Experimental Foods data may also be available through links to relevant agricultural research data sources, such as the AgCROS,. The data in Experimental Foods include (or link to) variables such as genetics, environmental inputs and outputs, supply chains, economic considerations and nutrition research. These data will allow users to examine a range of factors used that may affect the profiles of components and resulting dietary intakes as well as the sustainability of agricultural and dietary food systems.

1. Introduction

1.1 About Foundation Foods Found in FoodData Central

Foundation Foods is a more recent food composition data type in the U.S. Department of Agriculture's (USDA) FoodData Central system. Foundation Foods contains expanded component profiles and metadata on a range of foods and ingredients. The data include the individual data points behind the mean values and metadata that include the number of samples, location, dates on which samples were obtained, analytical methods used, and, if appropriate, agricultural information such as cultivar and production practices. The enhanced clarity and transparency of these data allow users to see the variability in the component values provided as well as the potential effects of the production site, procedures, season, climate, post-harvest processing, analytical methods, and other factors. Some of the data have been acquired through the historical National Food and Nutrient Analysis Program (NFNAP) (Haytowitz and Pehrsson, 2017). Data for newer Foundation Foods will come from market and/or agriculturally acquired foods. The goal of Foundation Foods will be to, over time, expand the number of basic foods and ingredients and their underlying data.

1.2 Foundation Foods Highlights

1.2.1 Updated Component Profiles

Macronutrients (protein, fat, and carbohydrate) are the energy sources in the human diet. The inaugural version of Foundation Foods included 73 foods that appeared in the final release of the National Nutrient Database for Standard Reference (SR Legacy). Since then, new acquisitions are added to Foundation Foods on a regular basis. Component profiles will now be focused on variability of individual samples and not weighted by market share. All individual sample analyses are available in FoodData Central.

1.2.2 Expanded Information on Foods

Acquired foods have multiple samples that contain unique metadata. A key feature of Foundation Foods is the ability to see the specific values associated with each independent sample and hence the variability of the analyzed values for each component. For samples obtained at retail locations, Foundation Foods contains metadata on sample acquisition, including city and state of purchase or manufacture, purchase date, expiration date (if applicable), product lot number, and UPC code (when available). For samples obtained from agricultural locations, metadata include information such as location (GPS coordinates), cultivar, weather, agricultural practices (e.g., conventional, or organic farming), and analytical methodology.

For SR Legacy, aliquots from composited samples were sent to USDA qualified laboratories and collaborators for analysis. Although this approach generated useable mean values, sample-to-sample variability was lost. Therefore, the generated statistical parameters reflected the variability of the analytical samples, not the individual samples composited for analysis. Historically, the goal of the analyses was to generate a reliable mean across up to 150 nutrients for highly consumed foods (per the NHANES What We Eat in America surveys) that reflected the composition the consumer was

statistically likely to encounter. Moving forward, all data will be reported for independent samples obtained for a single food acquisition. In some cases, multiple sales units from the same location may be needed to supply sufficient material for analysis. These will be treated as a single independent sample.

2 Details on Information in Foundation Foods

The data for Foundation Foods are organized into three major categories: Food Descriptions, Component Data, and Weights. These reflect the earlier approach to providing component profile data but may change as Foundation Foods evolves. In addition, support files are included that contain supplemental information related to these categories. File formats and related information are contained in the Download Field Descriptions, available on the FoodData Central website.

Data for agricultural products may be presented in forms not typically consumed but still representative of foods in the U.S. food supply. For example, data for common dry beans of different cultivars, growing locations, and climate conditions are presented on a 0% moisture basis rather than as sold.

2.1 Food Descriptions

The Food Descriptions category provides a full description of each food, including the name of the food, the brand name (if applicable), as well as the food's characteristics (e.g., raw or cooked, enriched or not, and color). Other fields in the Food Description file include:

- Scientific name.
- Common name, including alternative names for the product (e.g., dried beans), Uniform Retail Meat Identity Standard identification numbers, and USDA commodity codes as appropriate.
- Identification of food groups (see the Download Field Descriptions for more details) based on assignments in SR Legacy. These groupings are currently maintained to provide historical reference and continuity. It is anticipated that a current investigation in the area of ontology will result in changes in the food grouping systems.
- Amounts and physical descriptions, where appropriate, of refuse (inedible materials, such as seeds, bone, and skin). Refuse amounts are expressed as a percentage of the total weight of the item as acquired and are used to compute the weight of the edible portion. Most of the refuse data are obtained from measurements made for NFNAP samples.
- Factor used to calculate protein content from nitrogen content.
- Factors used to calculate number of kilocalories (kcal) from protein, fat, and carbohydrate, by difference.

Footnotes are provided for a few items where information about food description could not be accommodated in existing fields.

For details on the format of the Food Description file, see Download Field Descriptions.

2.2 Component Data

All values for components in Foundation Foods are based on analyses conducted by USDA under USDA's food composition, sampling, and analysis program or provided by other USDA units or external organizations. Newer Foundation Foods, as opposed to those previously reported in SR Legacy, will not have all components but will be targeting important components in that food. In some cases, foods analyzed for or before SR Legacy may also appear in Foundation Foods. For connectivity with SR Legacy foods, static NDB numbers will also appear as appropriate.

Foundation Foods are comprised of samples. A unique code or FDC Sample ID identifies individual samples for each food contained in each of the data types. Currently, an FDC Sample ID is assigned randomly when new or updated versions of foods are published in FoodData Central. However, when market and agricultural acquisition foods are presented through a Foundation Food, their FDC_IDs are labeled as FDC_Sample_ID to better distinguish them as samples comprising the current Foundation Food. The structure of this information is described in Download Field Descriptions. Details on each of these analyses can be accessed through the documentation available with each data type's download or through the "drill-down" capabilities (i.e., the ability to move from general information about a food to more detailed information) on the FoodData Central web site.

The raw analytical data are stored internally, as received. Before publishing to the public, they are rounded to scientifically appropriate significant figures, allowing ease in downloading, API, and data display.

Specific component values including protein, fat, and carbohydrates for energy, nitrogen for protein, and individual carotenoids and retinol for vitamin A, are stored in the data files to allow calculation of other components and may have more significant digits than are presented in the reports and data files. Therefore, small rounding errors may occur.

Foundation Foods does not provide data on all components for all foods. This is because of the uniqueness of the data:

- Some components are not found in certain foods (e.g., cholesterol in plant foods, protein in oils).
- Some components in a food have not yet been analyzed. Data analyses are continually conducted and as data on components are obtained, values will be added to food profiles.
- Therefore, not every sample for a food will have every component analyzed.

2.2.1 Proximates

"Proximate component" refers to the following macronutrients: water (moisture), protein, total lipid (fat), total carbohydrate, and ash. Except for a few food items, component profiles contain values for the proximate components and at least one other nutrient.

The values for protein are calculated from the amount of total nitrogen in the food using the nitrogen-to-protein conversion factors recommended by Jones (1941) for most food items. The factor applied to each food item is provided in the NFactor field in the Food Description table. If a specific factor is not available, the default value of 6.25 is used for the nitrogen-to-protein conversion factor. Protein values in Foundation Foods are now listed as "calculated." This differs from the approach taken in SR Legacy, which denotes protein as "analytical."

Total lipid values used on food labels represent the amount of triglyceride that would produce the amount of lipid fatty acids determined using gas chromatography, as required by the Nutrition Labeling and Education Act of 1990 (NLEA). The term "NLEA fat" is commonly used to refer to total fatty acids expressed as triglycerides.

Carbohydrate content, referred to as "carbohydrate by difference" in the tables, is expressed as the difference between 100 and the sum of the percentages of water, protein, total lipid (fat), ash, and alcohol (when present). Values for carbohydrate by difference include total dietary fiber content. "Sugars, total NLEA" refers to the sum of the values for individual monosaccharides (galactose, glucose, and fructose) and disaccharides (sucrose, lactose, and maltose), which are those sugars analyzed for nutrition labelling. Because the analyses of total dietary fiber, total sugars, and starch content are conducted separately and reflect the analytical variability inherent in the measurement process, the sum of these carbohydrate fractions may not equal the carbohydrate-by-difference value or may even exceed it.

2.2.2 Energy

Food energy is expressed in kcal and is no longer expressed in kJ as of October 2020. The data represent physiologically available energy, which is the value remaining after digestive and urinary losses are deducted from gross energy (Merrill and Watt, 1973). Energy values are calculated when fat and protein values are available for a food. Carbohydrate content, referred to as "carbohydrate by difference" in the tables, is expressed as the difference between 100 and the sum of the percentages of water, protein, total lipid (fat), ash, and alcohol (when present). Energy values on food labels may or may not include fiber in the carbohydrate and energy calculations because manufacturers have that option when reporting on labels. However, for Foundation Foods, fiber is often included in carbohydrate and energy distinctions when carbohydrate by difference is calculated.

Most energy values are calculated using the Atwater general factors of 4, 9, and 4 for protein, fat, and carbohydrates, respectively. These general calculations are represented in FoodData Central as "Metabolizable Energy (Atwater General Factor)" and is identified in download files and API with nutrient ID: 2047.

Other energy values are calculated using Atwater specific factors per food as outlined in the USDA Handbook 74. These specific calculations are represented in FoodData Central as "Metabolizable Energy (Atwater Specific Factor)" and is identified in download and API with nutrient ID: 2048.

In October 2020, energy values represented by "Energy", represented in the download and API with

ID:1008, will no longer display in FoodData Central's Foundation Foods, but will continue to display for the other food data types. In the database, this representation will continue to exist for previous API applications that require the field to function. API developers should work to implement the new Energy specifications.

2.2.3 Minerals

Individual values for mineral data are reported in the database and include boron, calcium, cobalt, copper, fluoride, iron, magnesium, manganese, molybdenum, nickel, phosphorus, potassium, selenium, sodium, sulfur, and zinc. For Foundation Foods previously reported in SR Legacy, regional and national averages are presented for fluoride, selenium and other mineral analyses based on samples for drinking water, select beverages, and grain-based products, respectively. These averages should be used as such, as concentrations in local foods and beverages may vary widely.

2.2.4 Vitamins

Vitamins reported in the database may include ascorbic acid, thiamin, riboflavin, niacin, pantothenic acid, vitamin B_6, vitamin B_{12}, folate, choline, vitamin A, vitamin D, vitamin E, and vitamin K. Many of the values were obtained in small sample sizes, often of composited samples for Foundation Foods previously reported in SR Legacy.

<u>Folate</u>

Foundation Foods currently provides folate values in micrograms (µg) of dietary folate equivalents (DFEs), and, in some cases, total folate. Future FoodData Central updates may present different forms of folate, including folic acid, food folate, and total folate, for some foods. Foundation Foods' DFEs are provided in accordance with the Institute of Medicine (IOM's) *Dietary Reference Intakes (DRI) for Thiamin, Riboflavin, Niacin, Vitamin B_6, Folate, Vitamin B_{12}, Pantothenic Acid, Biotin, and Choline* report (IOM, 1998). DFE concentrations differ from total folate concentrations only for foods containing synthetic folic acid added for enrichment or fortification. The calculation of DFEs reflects the greater bioavailability of synthetic folic acid than of naturally occurring food folate. To calculate DFEs for any single food, separate values are needed for naturally occurring food folate and added synthetic folic acid. The calculation is as follows:

µg DFE = µg food folate + (1.7 x µg folic acid)

<u>Choline</u>

Total choline, free choline (Cho), glycerophosphocholine (GPC), phosphocholine (PCho), phosphatidylcholine (PtdCho), and sphingomyelin (SM) from releases 1 and 2 of the USDA Database for the Choline Content of Common Foods (USDA, 2008) as well as newer values determined since the publication of those tables have been incorporated into Foundation Foods. Because metabolic pathways exist for the interconversion of Cho, GPC, PCho, PtdCho, and SM, total choline content is defined as the sum of the contents of these choline-contributing metabolites. Betaine values are not included in the calculation of total choline because the conversion of choline to betaine is irreversible (Zeisel et al.,

2003).

Vitamin A

Values for vitamin A in µg of retinolic acid equivalents (RAEs) and µg of retinol are reported. One µg RAE is equivalent to 1 µg all- *trans*-retinol, 12 µg all-*trans*-β-carotene, or 24 µg other provitamin A carotenoids. Vitamin A activity values in RAE are calculated from the content of retinol and individual carotenoids (β-carotene, α-carotene, and β-cryptoxanthin) using well-established factors (IOM, 2001). Content of individual carotenoids (β-carotene, α-carotene, β-cryptoxanthin, lycopene, and lutein plus zeaxanthin) is reported in Foundation Foods.

Vitamin D

Vitamin D values in Foundation Foods are provided in micrograms. The biological activity of vitamin D is 40 international units per microgram (IU/µg). Where available, values for specific isomers of vitamin D are reported, but only in µg. Cholecalciferol (vitamin D_3,) is the form that is naturally present in animal products and most commonly added to fortified foods. Ergocalciferol (vitamin D_2) is the form found in plants and is added to some fortified foods, such as soy milk. In Foundation Foods, vitamin D content is the sum of vitamin D_2 and vitamin D_3 concentrations. Vitamin D may also be present as 25-hydroxycholecalciferol in some foods, such as fish, meat, and poultry, and this value is reported when analytical data is available. The biological activity of 25-hydroxycholecalciferol has not been definitively determined, so it is not included in calculations of total vitamin D activity.

Vitamin E

The *Dietary Reference Intakes (DRI) for Vitamin C, Vitamin E, Selenium, and Carotenoids* report (IOM, 2000) defines vitamin E as the naturally occurring form (*RRR*-α-tocopherol) and three synthetic forms of α-tocopherol. Foundation Foods provides vitamin E values in mg of α-tocopherol (nutrient 323) in accordance with this DRI report. Although β-, γ-, and δ-tocopherol do not contribute to vitamin E activity, they are included in -Foundation Foods when analytical data are available.

Vitamin K

Data on vitamin K_1 (phylloquinone), dihydrophylloquinone, and menaquinone-4 are presented individually in Foundation Foods. Dihydrophylloquinone is a form of vitamin K that is created during the commercial hydrogenation of plant oils. Menaquinone-4 is formed from vitamin K_1 and/or the synthetic form of vitamin K in animal feed and is found primarily in meats and meat products.

2.2.5 Lipid Components

Fatty acid values are expressed in g per 100 g of food. Logically, the sum of the fatty acids may not add up to the value for total lipid. Total lipid values used on food labels represent the amount of triglyceride that would produce the amount of lipid fatty acids determined using gas chromatography, as required by the NLEA.

The basic format for describing individual fatty acids is that the number before the colon indicates the number of carbon atoms in the fatty acid chain, and the number after the colon indicates the number of double bonds. For unsaturated fatty acids, additional nutrient numbers have been added to

accommodate the reporting of many specific positional and geometric isomers. Of the specific isomers, two basic classifications are considered: omega double bond position and *cis/trans* configuration of double bonds.

Specific fatty acids will be depicted by an acronym before the number of carbon atoms in the chain and number of double bonds as follows: SFA for saturated; MUFA for monounsaturated; PUFA for polyunsaturated fatty acids. TFA will denote the trans arrangement of carbon atoms adjacent to the double bonds.

Omega-3 (n-3) and omega-6 (n-6) isomers are denoted in shorthand nomenclature as n-3 and n-6. The n- number indicates the position of the first double bond from the methyl end of the carbon chain. The letter *c* indicates a *cis* bond, and the letter *t* indicates a *trans* bond. For polyunsaturated fatty acids, *cis* and *trans* configurations at successive double bonds may be indicated. For example, linoleic acid is an 18-carbon omega-6 fatty acid with two double bonds, both in *cis* configuration. When data are isomer specific, linoleic acid is described as 18:2 n-6 *c,c.* Other isomers of 18:2, for which nutrient numbers have now been assigned, include 18:2 *c,t*, 18:2 *t,c*, 18:2 *t,t,* 18:2 *t* not further defined, and 18:2 *i.* 18:2 *i* is not a single isomer but includes isomers other than 18:2 n-6 *c,c* with peaks that cannot be easily differentiated in the particular food item. Systematic and common names for fatty acids are provided in Table 1.

Table 1. Systematic and Common Names for Fatty Acids

Fatty acid	Systematic name	Common name of most frequent isomer
Saturated fatty acids		
4:0	Butanoic acid	Butyric acid
6:0	Hexanoic acid	Caproic acid
8:0	Octanoic acid	Caprylic acid
10:0	Decanoic acid	Capric acid
12:0	Dodecanoic acid	Lauric acid
13:0	Tridecanoic acid	
14:0	Tetradecanoic acid	Myristic acid
15:0	Pentadecanoic acid	
16:0	Hexadecanoic acid	Palmitic acid
17:0	Heptadecanoic acid	Margaric acid
18:0	Octadecanoic acid	Stearic acid
20:0	Eicosanoic acid	Arachidic acid
22:0	Docosanoic acid	Behenic acid
24:0	Tetracosanoic acid	Lignoceric acid
Monounsaturated fatty acids		
14:1	Tetradecenoic acid	Myristoleic acid
15:1	Pentadecenoic acid	
16:1 undifferentiated	Hexadecenoic acid	Palmitoleic acid
16:1 *cis**		
17:1	Heptadecenoic acid	
18:1 undifferentiated	Octadecenoic acid	Oleic acid
18:1 *cis**		
20:1	Eicosenoic acid	Gadoleic acid
22:1 undifferentiated	Docosenoic acid	
22:1 *cis**		Erucic/citoleic acid
24:1 *cis*	Cis-tetracosenoic acid	Nervonic acid
Polyunsaturated fatty acids		
18:2 undifferentiated	Octadecadienoic acid	Linoleic acid
18:2 *i* (mixed isomers)		
18:2 n-6 *cis, cis**		
18:2 conjugated linoleic acid		
18:3 undifferentiated	Octadecatrienoic acid	Linolenic acid
18:3 n-3 *cis, cis, cis**		Alpha-linolenic acid
18:3 n-6 *cis, cis, cis*		Gamma-linolenic acid
18:3 *i* (mixed isomers)		
18:4	Octadecatetraenoic acid	Parinaric acid
20:2 n-6 *cis, cis*	Eicosadienoic acid	
20:3 undifferentiated	Eicosatrienoic acid	

Fatty acid	Systematic name	Common name of most frequent isomer
20:3 n-3		
20:3 n-6		
20:4 undifferentiated		
20:4 n-6*	Eicosatetraenoic acid	Arachidonic acid
20:5 n-3	Eicosapentaenoic acid	Timnodonic acid
21:5		
22:4		
22:5 n-3	Docosapentaenoic acid	Clupanodonic acid
22:6 n-3	Docosahexaenoic acid	
Trans fatty acids		
Fatty acids, total trans-monoenoic		
16:1 *trans*		
18:1 *trans*		
22:1 *trans*		
Fatty acids, total trans-polyenoic		
18:2 *trans* not further defined		
18:2 *trans, trans*		

*Isomer associated with the common name; the most frequent isomer is listed for the undifferentiated fatty acid. It is not possible to include every possible geometric and positional isomer in the database. Where specific isomers exist for a fatty acid, the common name of the most frequent isomer is listed for the undifferentiated fatty acid and an asterisk (*) designates the isomer to which that name applies. For example, the most frequent isomer for 18:1 is oleic acid. Therefore, undifferentiated 18:1 is designated in Table 1 as oleic acid, and the asterisk indicates that the common name for 18:1, oleic acid, only applies to this isomer.

Because cholesterol is found only in foods of animal origin, cholesterol values are provided only for foods of animal origin and foods containing at least one ingredient of animal origin.

2.3 Weights

Portions are provided in grams for edible material without refuse (i.e., the edible portion of the food), such as an apple without the core or stem or a chicken leg without the bone. All reported values are based on a 100-gram or percent basis of the edible portion. Also provided for some foods is information on portion sizes (e.g., 1 cup, 1 tablespoon, 1 fruit, or 1 leg).

Although FoodData Central does not contain a way to automatically modify portion sizes and thus component values, this functionality is available in the What's in the Foods You Eat search tool, located on the Food Surveys Research Group website. The Measurement Conversion Tables located on the Methods and Application of Food Composition Laboratory site provide a listing of measurements and their equivalents commonly used for food and beverages. These weights are determined from samples acquired as part of NFNAP. It should be noted that portions and weight are unique to each data type in FoodData Central—Foundation Foods, Food and Nutrient Database for Dietary Studies (FNDDS), SR Legacy, and

USDA Global Branded Food Products Database. In some cases, there may be many more determinations of portion sizes than there are of the component analyses. Portions for specific foods are displayed in the measure tab on the FoodData Central website or in the food portion file in the download files; the format of this file is described in the Download Field Descriptions.

The gram weights in the food portion file can be used to calculate nutrient values for food portions from the values provided per 100 g of food. The following formula is used to calculate the nutrient content per portion:

N = (V*W)/100;

where:
N = nutrient value per portion size,
V = nutrient value per 100 g (Nutr_Val in the Nutrient Data file), and
W = weight (in g) of portion (Gm_Wgt in the Weight file).

2.4 Limits of Quantification

Limit of Quantification (LOQ) is the lowest amount of measure in a sample that can be quantitatively determined with acceptable precision and accuracy. In FoodData Central, LOQ values are represented with less than (<) values. LOQ values may not be available for component values in older Foundation Foods. Calculations performed such as component totals and statistical averages use zero to calculate results. In addition, unavailable LOQ values may be reported as zeros.

In the download files and API, a new field has been added for LOQ values. LOQ values are stored as numbers and component values are stored as 0. For example: an LOQ of <0.03 is stored in the LOQ field as 0.03 and in the component value field as 0.

3 Reports and Data Files

3.1 Foundation Food Search Results

Using the FoodData Central search program (fdc.nal.usda.gov), users can look up the component content of any food in Foundation Foods as well as those in SR Legacy, FNDDS, and the USDA Global Branded Food Products Database. Foods may be selected by key terms, such as component name, food name, NDB# (in SR Legacy), FDC_ID number, or brand (in USDA Global Branded Foods Database). Searches can be made more precise by using search operators. For more information see the FoodData Central's Help Page.

An application program interface (API) is also available for developers to use to access the database with their own applications. They can be assured that they are linking to the most up-to-date version of the database. Details on using the API are provided on the FoodData Central web site (fdc.nal.usda.gov).

3.2 Overview of Data Tables

The data files for Foundation Foods are available from the FoodData Central web site (fdc.nal.usda.gov) in ASCII (ISO/IEC 8859-1), and Microsoft Access 2016 formats.

Descriptions of each field in these tables and the relationships between them are contained in the Download Field Descriptions.

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