

A BRIEF HISTORY OF THE U.S. DEPARTMENT OF AGRICULTURE'S NUTRIENT DATA BANK

*David B. Haytowitz*¹

**United States Department of Agriculture
Hyattsville, Maryland, USA**

The U.S. Department of Agriculture has been collecting, evaluating, and publishing food composition data for nearly a century. The first food composition table was published in 1892 by Atwater and Woods and was entitled "Investigations Upon the Chemistry and Economy of Foods" (1). Information on this table and subsequent food composition tables is given in Table 1.

Currently, *Agriculture Handbook No. 8*, first published in 1950 and revised in 1963, is being revised in sections by food groups (Table 2) (13). Data collection and aggregation, once performed manually, are now done with the aid of computers. To date, 19 of 22 sections have been released and work is under way on the remaining three sections as well as an annual supplement to most of the earlier sections. Nutrient values are presented on proximate components, nine minerals, nine vitamins, up to 19 fatty acids, cholesterol, phytosterols, and 18 amino acids, and are given in terms of amount in 100 grams of edible portion, in two common measures, and in one pound of food as purchased. Standard error and number of samples are also listed. Food energy is expressed as kilocalories and kilojoules, and vitamin A is expressed in both retinol equivalents and international units. The data, in addition to being available in printed form, are available in machine-readable versions that are becoming increasingly popular.

Although this revision is nearly complete, the need for future updates and revisions will remain. For example, recent "market-basket" research shows that more fat is trimmed from beef cuts in the US market than previously reported. Therefore, to incorporate these new findings, the 1986 section on beef (No. 8-13) is being revised. The first annual supplement to the published sections was issued in

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1 Nutritionist, Nutrient Data Research Branch, USDA - Nutrition Monitoring Division, Federal Building, Hyattsville, Maryland 20782, USA.

TABLE 1
U.S. FOOD COMPOSITION TABLES: 1892 TO THE PRESENT

Title and Authors	Date	Nutrients In Table	Number of Foods	Comments
"Investigations Upon the Chemistry and Economy of Foods" (1)	1892	Proximates	2,600 analyses	First food composition table
"The Chemical Composition of American Food Materials" U.S. Dept. Agric. Bull. No. 28. (2)	1896	Proximates	Over 4,000 samples	
"The Chemical Composition of American Food Materials" U.S. Dept. Agric. Bull. No. 28. (Rev. ed.) (3)	1899	Proximates	Over 4,000 samples	
"The Chemical Composition of American Food Materials" U.S. Dept. Agric. Bull. No. 28. (2nd Rev. ed.) (4)	1906	Proximates	Over 4,000 samples	
"Proximate Composition of Beef" U.S. Dept. Agric. Cir. No. 389. (5)	1926	Proximates	49	
"Proximate Composition of Fresh Fruits", U.S. Dept. Agric. Cir. No. 50. (6)	1928	Proximates	98	
"Proximate Composition of Fresh Vegetables", U.S. Dept. Agric. Cir. No. 146. (7)	1931	Proximates	124	
"Proximate Composition of American Food Materials", U.S. Dept. Agric. Cir. No. 549. (8)	1940	Proximates and crude fiber	1,633	Calories calculated from data on proximates
"Tables of Food Composition in Terms of Eleven Nutrients", Bureau of Human Nutrition and Home Economics in cooperation with the National Research Council. U.S. Dept. Agric. Misc. Publ. No. 572 (9)	1945	Protein, fat, carbohydrate, calcium, phosphorus, iron, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid	275	Data presented in two tables: 100 grams edible portion and 1 pound as purchased
"Composition of Foods-Raw, Processed, Prepared", U.S. Dept. Agric. Handb. No. 8. (10)	1950	Protein, fat, carbohydrate, calcium, phosphorus, iron, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid	751	First food composition table called Handbook No. 8
"Composition of Foods-Raw, Processed, Prepared" U.S. Dept. Agric. Handb. No. 8. (11)	1963	Protein, fat, carbohydrate, calcium, phosphorus, iron, sodium, potassium, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid	2,483	Data also presented for selected fatty acids, cholesterol and magnesium in selected foods
"Nutritive Value of American Foods in Common Units", U.S. Dept. Agric. Handb. No. 456. (12)	1975	Same nutrients as AH-8 (1963).	2,483	Data presented in terms of common household units
"Composition of Food: Raw, Processed, Prepared", Agric. Handb. No. 8. (13)	1976 - present	Proximates, 9 minerals, 9 vitamins, up to 19 fatty acids, cholesterol, phyto-sterols, and 18 amino acids.	3,515	19 of 22 sections have been published. Data presented for 100 grams, two household units and one pound as purchased

TABLE 2
AGRICULTURE HANDBOOK No. 8 SERIES

Series No.	Food group	Year issued	Number of items
8-1	Dairy and Egg Products	1976	144
8-2	Spices and Herbs	1977	43
8-3	Baby Foods	1978	217
8-4	Fats and Oils	1979	128
8-5	Poultry Products	1979	304
8-6	Soups, Sauces, and Gravies	1980	214
8-7	Sausages and Luncheon Meats	1980	80
8-8	Breakfast Cereals	1982	142
8-9	Fruits and Fruit Juices	1982	263
8-10	Pork Products	1983	186
8-11	Vegetables and Vegetable Products	1984	470
8-12	Nut and Seed Products	1984	117
8-13	Beef Products	1986 ¹	360
8-14	Beverages	1986	153
8-15	Finfish and Shellfish Products	1987	174
8-16	Legumes and Legume Products	1986	133
8-17	Lamb, Veal, and Game Products	1989	221
8-18	Baked Products	In preparation	
8-19	Snacks and Sweets	In preparation	
8-20	Cereal Grains and Pasta	1989	118
8-21	Fast Foods	1988	166
8-22	Mixed Dishes	In preparation	
	1989 Supplement	1990	96

¹ New revision in preparation.

January 1990. This supplement adds new items and updates and revises data contained in 14 of the earlier sections. Several sections are slated for complete revisions. Among these are the sections on Baby Foods, Breakfast Cereals, and Sausages and Luncheon Meats. Work will commence on these sections as resources allow. Nutrient data on other food items will be updated through annual supplements; work has already begun on the 1990 supplement.

The history of USDA's Nutrient Data Bank has been described previously (14). The Nutrient Data Bank is maintained by the Nutrient Data Research Branch (NDRB), which is part of the Nutrition Monitoring Division of the Human Nutrition Information Service (HNIS). The Nutrient Data Bank System (NDBS), which has recently

been revised and rewritten to take advantage of advances in computer technology, consists of two major parts. One is a number of programs, comprising approximately 113,000 lines of code, which enable NDRB staff to add, update, report, or delete data in the NDBS. The other major part of the NDBS is, of course, the data. To date, over one million records have been entered into the NDBS. Two types of data are maintained in the NDBS. The first type of data consists of a number of support files. Examples of these include files containing food codes, qualifiers, and nutrient numbers. The second type of data in the NDBS is the nutrient data. Combined, there are almost 200 files in the NDBS system.

SUPPORT FILES

Foods are classified by using a food code in combination with a number of qualifiers. Food codes are four-character, alphabetic codes organized into 21 major groups. Each of these major groups is in turn subdivided into a number of subgroups depending on the food group. For example, food group 'N'—vegetables and vegetable products—is divided into subgroups based on major classes of vegetables, such as root vegetables and leafy greens. These subgroups are further divided to describe a particular vegetable, which in turn can be subdivided to describe a particular cultivar of that vegetable.

Qualifiers are used to provide additional information about the food beyond that in the food code. Qualifiers are four-character, alphanumeric codes organized into 12 major groups. They are used to describe factors such as treatment applied, cooking methods, country of origin, grade, added ingredients, and other factors that can affect the nutrient content of the food and are needed for proper coding of the data in the NDBS.

Together, food codes and qualifiers are used to describe all foods entered into the system. Presently we have almost 12,000 food codes and about 4,300 qualifiers in the NDBS system, enabling us to identify all foods. When a new food is identified, appropriate food codes and qualifiers are added to the NDBS system by a specialist assigned to this task.

A unique three-digit number is assigned to each nutrient and other food composition factors such as ash, cholesterol, and pH. At this time we have over 330 nutrients and other food composition factors. As needed additional items can be added. For each nutrient value a method code is also entered. This code describes various steps in the analytical method, such as extraction technique and quantifications steps. The source of the data is also coded.

Other support files include a measurement conversion file, which is used to convert nutrient values into standard units. A retention factor file is used in recipe calculations. Additional support files are used to produce the *Agriculture Handbook No. 8* pages. There is also a security file, which is used to restrict access to a particular food group to those staff members working on it. This reduces the odds of

accidentally deleting or modifying a nutrient record.

SOURCES OF DATA

The Human Nutrition Information Services (HNIS) acquire data from many sources. Among these are contracts sponsored by HNIS with universities and commercial laboratories, and contacts made with researchers in the food industry, academia, and other Government agencies. The food industry supplied much data that they had developed for use in nutrition labelling programs. Another major source of data is the scientific literature. Here, we depend on abstract journals such as *Food Science and Technology Abstracts* produced by the International Food Information Service, and *Nutrition Abstracts* produced by the Commonwealth Agricultural Bureau. Computerized literature searches of these data bases are run regularly at the National Agriculture Library in Beltsville, Maryland. Reprints of desired articles are obtained from the same source. We also subscribe directly to a number of food science and nutrition journals. If we find that nutrient data for a food has changed, either due to improved methodology, better sampling, or product reformulation, we can report the new data in our annual supplement.

Once we receive a document, whether a journal article or a contract report, it is reviewed by Nutrient Data Research Branch (NDRB) staff to determine if the data can be used in the NDBS. If the article contains reliable data, they are coded for entry into the NDBS. If there are any questions about the data, the researcher is contacted for clarification before the data are used.

DATA ENTRY

After the data have been coded onto specially designed forms, they are entered into a computer file. Data are entered once by two different individuals and compared by the use of special programs to insure that there are no data entry errors. The file is then loaded into the first of three data bases. This first data base is called "data base 1" or "B1.". At this point, the NDBS checks to insure that all codes were entered correctly (that is, they are known to the system). For example, definitions of food codes and qualifiers are reported at this time. If there is an error in the file, an error message is printed and the record cannot be released to the "production" environment until the error is corrected. For example, an error exists if a food code or qualifier code is not in the appropriate support files.

All data are entered in standard units. If the data are reported in different units, the system has the ability to convert data to the required standard units. For example, folacin values are stored in the NDBS in micrograms; however, if a researcher reports results in terms of milligrams, the results are converted to micrograms. Similarly, all NDBS data are for the fresh-weight basis of the foods. If data

are supplied for the dry-weight basis, they are converted to fresh weight if values for moisture or total solids are available. If the moisture or total solids values are not available, attempts will be made to contact the researcher in order to acquire this information. If these attempts are unsuccessful, the data will not be entered and will be held for possible use when a mean moisture value for the food is available.

The data of analysis is also entered. We can also indicate if the nutrient value is affected by added ingredients, such as vitamins and iron in enriched flour. The system handles either individual values or mean values. For mean values the number of samples, low value, high value, and standard deviation are also entered. If individual values are entered, the mean, standard deviation, and high and low values of those individual values are calculated and reported.

Initially, data are placed in the "test" environment. Here data can be reviewed by the food specialist and, if necessary, revised or deleted. Reviewed data are released to the "production" environment, where they are available for use in the next step. If a data element is later found to need revision it can be moved back to the "test" environment for updating. It is then "re-released" to the "production" environment.

B2 — THE FIRST SUMMARY

The next step in the NDBS is the aggregation of B1 records to create "data base 2" or "B2." The aggregation procedure uses Boolean logic to select records with like food codes and qualifiers. By the use of appropriate logic, various aggregations can be defined, excluding B1 records with certain food codes and qualifiers, or including only B1 records with particular food codes or qualifiers, or including any B1 records with any of several different food codes and qualifiers. Logic statements can be quite simple or rather complex, depending on the nature of the food group and how the data were coded in B1. For example, at this step data from different countries or different food processors can be kept separate.

An example of a simple logic statement would be:

```
FC EQ NAR* AND
QC EQ E232 AND
QC EQ E211 AND
UC EQ 0
```

"FC" indicates food code; the "EQ" means "equal." We can also use "not equal" to exclude certain food codes or qualifiers. "NAR*" is the food code for carrots. The asterisk at the end substitutes for the letters A to Z. Therefore, this logic statement would capture food codes NARA to NARZ. The "AND" indicates that this statement is linked with the next statement and both must be true. We can also use "OR" where only one of the statements has to be true. "QC" indicates a qualifier code. In this example we have two qualifiers, and both

have to be in the B1 record in order to satisfy this logic. "E232" is the qualifier code for raw and "E211" is the code for unprepared. "UC" means "use code," which is used to separate data on proximates, minerals, and vitamins from that on fatty acids and amino acids. These are collected by different staff members and are not combined until later.

Combined, these four logic segments would select all proximate, mineral and vitamin data for raw and unprepared forms of all varieties of carrots. Data for carrots cooked from raw would not be included, nor would data on canned, unprepared or frozen, unprepared carrots be included: those records contain only one of the two required qualifiers. Data on fatty acids and amino acids also would not be included because they were entered with a different use code.

An example of a more complex logic statement is:

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(FC EQ LABC,LABD OR
FC EQ LABE,LABY) AND
QC EQ E082,K392 AND
QC NE D104,D107 AND
UC EQ 0
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This logic would create a B2 record with all proximate, mineral, and vitamin data (UC = 0) for several varieties of rice (FC = LABC,LABD,LABE,LABY) which has not been cooked, that is dry (QC = E082) or uncooked (QC = K392) and is not parboiled (QC = D104) or precooked (QC = D107). Parentheses are used to group logic segments.

The food specialist keeps data separate based on factors that could affect the nutrient content, such as processing or preparation steps, nutrients added for enrichment or fortification, or the use of various nutrient-containing food additives. Initially these data are also placed in the B2 "test" environment, where then can be reviewed. If needed, the aggregation logic can be changed and the aggregation process rerun. B1 records that do not meet the logic definition can be added manually. Unwanted records can be removed.

During the aggregation process the mean, standard error, number of samples, high value, and low value of the B1 records captured by the logic statement are determined, reported, and stored in the B2 record.

At this time, total carbohydrate is calculated by subtracting the sum of the protein, fat, moisture, and ash values from 100. Total carbohydrate includes fiber, which is reported separately. In the past we have entered only data on crude fiber. As analytical methodology has improved, data have become available on total dietary fiber and its fractions, as well as on other carbohydrate fractions, such as sugars and starch components. At first we published data on insoluble dietary fiber as determined by the neutral detergent fiber method. These data were generally placed in footnotes to those food items for which we had data. With the development of the Prosky method for determining total dietary fiber, we have begun to report those values, either as footnotes or in appendix tables. These data are

also included on machine-readable forms of the data. Data on total dietary fiber have also been published in a provisional table (15). Data on sugars have also been published in a separate publication, *Home Economics Research Report No. 48*, "Sugar Content of Selected Foods: Individual and Total Sugars" (16).

Protein is also calculated from nitrogen using the factors of Jones *et al* (17), which are stored in one of the support files. When a food is composed of two or more ingredients, nitrogen-to-protein conversion factors are calculated based on the proportion of each ingredient. Food energy is also calculated by multiplying grams of protein, fat and carbohydrate by appropriate factors. These factors, taken from *Agriculture Handbook No. 74* (18), are also stored in one of the support files in the NDBS. When a food is composed of two or more ingredients, calorie factors are calculated based on the proportion of each ingredient. If necessary, a particular B2 record.

During the aggregation process, fatty acid calculations are performed. If the data were entered in terms of methyl esters, they are converted. Data on the individual fatty acids are converted to grams of fat per 100 grams of fat. Values for total saturated, total monounsaturated, and total polyunsaturated fatty acids are also calculated. Data on amino acids are also compiled at this time and are expressed in terms of grams of amino acid per gram of nitrogen. At the B2 level, records containing proximates, minerals and vitamins are kept separate from those containing amino acids, and fatty acids. Once the B2 data have been reviewed by NDRB food specialists, they are released from the test environment to the production environment for further processing.

B3 — A FURTHER SUMMARY

The next step is the aggregation of B2 records to create "Data Base 3" or "B3" records. B2 records to be aggregated to create a B3 record are not selected by using a logic statement as was done to create the B2 record, but are selected by the food specialist. The food specialist also selects appropriate weighting factors for each B2 record to be combined to create the B3 records. For example, data from different food processors or growing locations can be combined with different weighting factors to reflect market share or production data, assuming they were kept separate at the B2 level. Alternatively, all data can be treated equally so that a large amount of data from a minor source of a food does not outweigh small amounts of data from a major source. For example, in the case of canned vegetables, a review of market data showed that private-label or store brands had a major portion of the market, yet most of the nutrient data were from several national canners. It was decided to treat all these data equally so that no one source would bias the data. This decision was based on statistical analyses, which often show more variation within a company than between companies.

In the above example, where we wanted data from different

processors treated equally, we would assign each B2 record the same weighting factor. If, for example, company A controlled 50% of the market and companies B and C each controlled 25%, we would assign the data from company A a weighting factor of 50 and the data from companies B and C a weighting factor of 25. The system would then calculate a B3 record based on these weighting factors.

At the time the B3 record is created, the B2 records containing the amino acids and the fatty acids are selected by the food specialist and added to the new B3 record. Amino acid data are converted from grams of amino acid per gram of nitrogen to grams of amino acids per 100 grams of food. Fatty acid data are converted from grams of fatty acid per 100 grams of fat to grams of fatty acid per 100 grams of food.

As in earlier steps, the B3 records are initially placed in the "test" environment for review or revision. Once reviewed they are released to the "production" environment.

The NDBS also has the capability of creating B3 records based on a "recipe" program. This procedure used in the NDBS has been discussed in detail by Perloff (19). In this procedure, the food specialist indicates which B3 components are used and the quantity used in the food item. The food specialist can also specify percentage yield by indicating, where applicable, moisture gain or loss and/or fat gain or loss. If a fat change is specified, the type of fat lost or gained is also specified. The system also adjusts the nutrient values of vitamins and minerals for losses during processing or preparation by the use of appropriate nutrient retention factors. Here also, the records are initially placed in a "test" environment for review before release to the "production" environment. This "recipe" procedure allows us to include items for which no analytical data exist. For example, calculating values for a cooked cereal is possible by applying appropriate yield and retention factors to the values for the raw cereal. The nutrient content of mixed dishes can also be calculated.

Values in B3 are published in *Agriculture Handbook No. 8*; however, some additional information is needed to produce the handbook tables. Household weights and refuse percentages are determined by the food specialist and entered into the system. The system then generates reports and files used for the preparation of camera-ready copy by our word processing unit. At this time the nutrient values in terms of two household weights and 1 pound as purchased are calculated. Also, food energy in kilojoules and vitamin A in retinol equivalents are calculated. Text, appendix tables (such as calorie factors, retention factors, and yield data), a guide to the section, explanatory footnotes, and other descriptive information, such as scientific names, are added.

In addition to the extensive list of nutrients published in Handbook 8, many other nutrient values can be entered into the NDBS. These are used to produce other reports and to answer the many questions we receive from consumers, health-care professionals, and researchers around the world.

PUBLICATIONS AND MACHINE-READABLE DATA

The completed Handbook 8 sections are available for sale through the Government Printing Office, located in Washington, DC. Before or soon after publication, work commences on preparing the machine-readable version — the USDA Nutrient Data Base for Standard Reference (NDB-SR). The NDB-SR contains all the data in the revised sections, including data from footnotes and appendix tables. If data from a footnote changes a nutrient value in the table, a new item is added to the NDB-SR containing the footnote value and other data for that food item. The data from the 1963 edition of Handbook 8 is also included for unrevised food items. New releases of the NDB-SR are issued periodically, approximately once a year, as new sections of the Handbook are published. The latest release available is Release 8, which includes sections 1 through 17, 20, and 21, plus data from the 1989 supplement.

In addition to the data file itself, a "coding manual" is prepared. The coding manual contains a full description of the food item (a shorter description is on the data file itself), descriptions, and conversion factors for the household weights and pound-as-purchased columns. As new sections are released, data from the 1963 Handbook are removed. These items are generally those which are no longer available or have been removed from the market. Additional files containing lists of items to be removed from earlier releases of the NDB-SR and a list of new items and the old items they replace are also provided. These files are most useful to organizations that have purchased earlier releases of the data and need update their data bases.

The NDB-SR is available from the National Technical Information Service in Springfield, Virginia, 22161, USA. It is available on both magnetic tape and on diskettes formatted for a personal computer using MS-DOS. Other formats are available on request. Data sets are also available to update earlier releases of the NDB-SR. This and other nutrient data sets are described in *Administrative Report No. 378, "Machine-Readable Data Sets on Composition of Foods and Results from Food Consumption Surveys"* (20) which is available from our office. We have also established an electronic bulletin board that contains information on food composition publications, machine-readable data sets and other information related to the Nutrient Data Bank.

NDB data are also used to generate other publications and reports of the US Department of Agriculture. Data from the NDB-SR and unpublished data are used in the Department's Food Consumption Surveys (both the Continuing Survey of Food Intakes by Individuals and the recently completed 1987-88 USDA Nationwide Food Consumption Survey, Individual and Household).

Data are taken from the NDB-SR and supplemented with new data on additional foods and nutrients not reported in the NDB-SR. These data make up the Primary Nutrient Data Set for Food Consumption Surveys (PDS). New items can be quickly added to the PDS

to include foods reported as consumed in the surveys. Items in the PDS are used to generate the USDA Nutrient Data Base for Food Consumption Surveys by the use of a linking file. This linking file contains information on how to combine PDS items and, when appropriate, moisture loss or gain and fat loss or gain factors. Retention factors are also available to adjust for nutrient losses during preparation or processing. A computer program then generates the survey nutrient data base. This program calculates nutrient data in the same manner as the "recipe" program in the NDBS discussed earlier. This procedure has been adapted for the personal computer by the University of Texas and HNIS. The nutrient data files used in the Survey are also available and are described in Administrative Report No. 378.

These data are also being used by the U.S. DEPARTMENT OF HEALTH And Human Services for the Third National Health and Nutrition Examination Survey (NHANES-III), currently under way.

The compilations and dissemination of food composition data have been an historic role of the US Department of Agriculture for nearly a century. As we enter our second century of preparing food composition tables, we look for an increasing role for computers in making important nutrient data available to those individuals in various disciplines who use them.

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