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Report

The National Food and Nutrient Analysis Program: A decade of progress

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Abstract

The National Food and Nutrient Analysis Program (NFNAP) was designed to expand the quantity and improve the quality of data in the United States Department of Agriculture (USDA) food composition databases through the collection and analysis of nationally representative samples of foods and beverages. This paper describes some of the findings from the NFNAP and its impact on the food composition databases produced by USDA. The NFNAP employs statistically valid sampling plans, comprehensive quality control, and USDA analytical oversight to generate new and updated analytical data for food components. USDA food consumption and composition data were used to target those foods that are major contributors of nutrients of public health significance to the U.S. diet (454 Key Foods). Foods were ranked using a scoring system, divided into quartiles, and reviewed to determine the impact of changes in their composition compared to historical values. Foods were purchased from several types of locations, such as retail outlets and fast food restaurants in different geographic areas as determined by the sampling plan, then composited and sent for analysis to commercial laboratories and cooperators, along with quality control materials. Comparisons were made to assess differences between new NFNAP means generated from original analytical data and historical means. Recently generated results for nationally representative food samples show marked changes compared to database values for selected nutrients from unknown or non-representative sampling. A number of changes were observed in many high consumption foods, e.g. the vitamin A value for cooked carrots decreased from 1225 to 860 RAE/100 g; the fat value for fast food French fried potatoes increased by 21% (14.08–17.06 g/100 g). *Trans* fatty acids in margarine have decreased as companies reformulate their products in response to the required addition of *trans* fatty acids content on the nutrition label. Values decreased from 19.7 g/100 in 2002 to 14.8 g/100 in 2006 for 80%-fat stick margarines and to 4.52 g/100 g for 80%-fat tub margarines. These changes reflect improved strategies for sampling and analysis of representative food samples, which enhance the reliability of nutrient estimates for Key Foods and subsequent assessments of nutrient intake.
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Keywords: USDA food composition database; National nutrient database; Food tables; Nutrient data; National Food and Nutrient Analysis Program (NFNAP); Data management; Key Foods; Database update

1. Introduction

The U.S. Department of Agriculture (USDA) has maintained tables of food composition for over 115 years, since the pioneering work of Atwater (Atwater and Woods, 1892). Published in 1892, the Atwater table of 178 food items contained data on five proximate components (water, protein, fat, total carbohydrates and ash), calories (called fuel in the Atwater table) and refuse. As early as 1940, Chatfield noted the ongoing need to update these tables as food, agricultural, and manufacturing practices changed to reflect consumer preferences for low cost, nutritious, and more palatable foods (Chatfield and Adams, 1940). Today, the Nutrient Data Laboratory (NDL), Agricultural Research Service (ARS), USDA generates the National Nutrient Database for Standard Reference (SR), which provides the sound scientific foundation for food composition data in the U.S. The most current update is Release 19, which contains data for 7291 food items for up to 140 nutrients and other components (NDL, 2006b). Special interest databases on emerging bioactive components such

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as flavonoids and isoflavones, as well as new databases on fluoride and choline, are also produced to supplement the "flagship" SR database. These databases meet increasing demands from health professionals providing dietary guidance, nutrition policy makers, researchers studying the relationships between food and health, and consumers interested in what is in the foods they eat.

Since 1997, the National Food and Nutrient Analysis Program (NFNAP) has been conducted by NDL in cooperation with the National Institutes of Health (NIH), the Centers for Disease Control (CDC), and the Food and Drug Administration (FDA). NFNAP is a dynamic, nationally representative food analysis program, with the goal of improving the quality and quantity of data in USDA food composition databases. At the start of the program, the National Heart, Lung and Blood Institute of the NIH provided coordination for 17 Institutes, Centers and Offices of the NIH and other Federal partners. More recently, the National Cancer Institute has assumed the coordination role at NIH. The five principal aims of the program are to:

- Identify Key Foods and critical nutrients for sampling and analysis;
- Evaluate existing data for scientific quality;
- Devise and implement a probability-based sampling survey of U.S. foods;
- Analyze sampled foods under USDA-supervised laboratory contracts; and
- Compile newly generated data to update USDA food composition databases.

These aims have guided the conduct of the program. To support the aims, standardized protocols and procedures have been developed. These, along with the organization and flow of sample units, analytical samples, and data, define the infrastructure of the NFNAP (Fig. 1).

2. Methods

2.1. Identify Key Foods and critical nutrients for sampling and analysis

The Key Foods process uses food composition and food consumption data to identify and prioritize foods and nutrients for analysis (Haytowitz et al., 2000, 2002). Key Foods are those foods, which in aggregate, contribute 75% of the nutrient intake for selected nutrients of public health importance from the diet.

The latest Key Foods list was generated using weighted two-day food consumption data from the National Health and Nutrition Examination Survey (NHANES) 2003–2004 Data Files (NCHS, 2006) and food composition data from the SR18 (issued in 2005). For the current Key Foods list, targeted nutrients (total fat, food energy, total sugar, calcium, iron, potassium, sodium, zinc, vitamin A, β-carotene, α-tocopherol, vitamin C, vitamin B12, folate, cholesterol and saturated fatty acids) were those identified in the Dietary Guidelines Advisory Committee Report on the Dietary Guidelines for Americans, 2005 (DGAC, 2004) as "shortfall" nutrients (limited in the diet) or nutrients of excess consumption, in particular those associated with poor health status. Other nutrients of concern such as *trans* fatty acids and added sugar were considered but not included in the Key Foods algorithm as only those nutrients included in the Food and Nutrient Database for Dietary Surveys (FNDDS), 2.0 (FSRG, 2006) could be used. The Key Foods approach has allowed NDL to

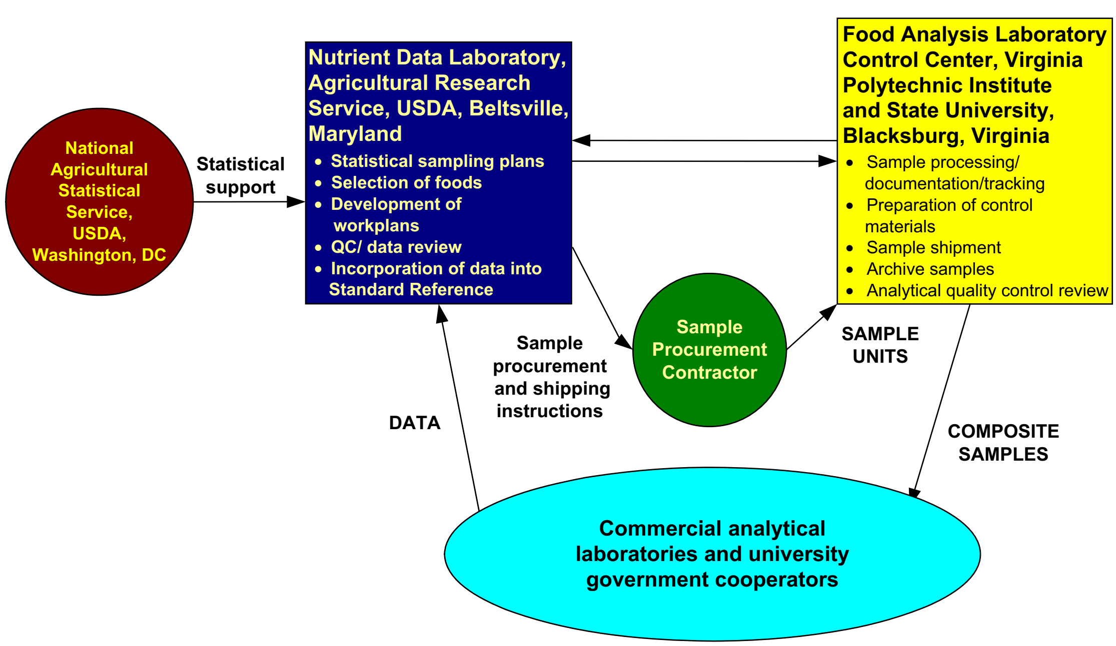

Fig. 1. Infrastructure of the National Food and Nutrient Analysis Program.

concentrate analytical resources on those foods that contribute significant amounts of nutrients of public health interest to the diet.

2.2. Evaluate existing data for scientific quality

At the initiation of NFNAP in 1997, the food composition values in SR were reviewed for scientific quality by NDL staff. Data for many of the foods in the database at that time were found to be more than 10 years old and based on a limited number of values, lacked complete and accurate documentation, and included some samples of uncertain origin. To assess the quality of existing data and to improve the level of documentation, NDL scientists developed an expert system for evaluating data quality (Holden et al., 2002, 2005). The expert system allows documentation and evaluation of five categories of information: sampling plan; sample handling; the number of samples analyzed; analytical methodology; and analytical quality control. This system has been used in the production of a number of special interest databases on isoflavones (NDL and ISU, 2002), choline (NDL, 2004a), proanthocyanidins (NDL, 2004b), fluoride (NDL, 2005), and flavonoids (NDL, 2007). Many of the food profiles in the database were found to be missing all or some of the expert system information. For these reasons, and to establish a core set of data of known sampling, analytical methodology, and quality control, it was determined that a comprehensive update of the food items on the Key Foods list would be needed.

2.3. Devise and implement a probability-based sampling survey of U.S. foods

A probability-proportional-to-size food sampling plan was developed by NDL staff in collaboration with statisticians from the National Agricultural Statistics Service, USDA (Pehrsson et al., 2000). The original NFNAP food product sampling design was stratified in three stages and used adjusted 1990 census data for four geographic regions (nearly equal in population size) across the 48 conterminous states. A revised sample design was developed with 2000 Census data (Perry et al., 2003) and was also based on a stratified three-stage design using 2001 Census Bureau projected state population sizes and Census regions (U.S. Census Bureau, 2002). As with the original approach, forty-eight geographically dispersed counties were selected at the first stage, grocery store outlets at the second stage, and specific food products at the third stage. Subsets of these locations can be selected according to the requirements of the specific food item and nutrients. For example, nutrients with greater variability, such as fluoride, would be sampled in more locations. Another consideration in designing the sampling strategy was that fewer samples would be analyzed for lower consumption foods as identified during the Key Foods process or for nutrients found at lower concentrations. Details of the nationally representative sampling design are discussed in Perry et al. (2003).

Specific food products were selected according to a sampling approach based on market share. For example, after examining the Key Foods list, it was determined that pizza was a major contributor of many nutrients. However, the SR Link file in the FNDDS does not differentiate between pizzas purchased from a fast food pizza restaurant vs. those purchased frozen, and then heated and served at home. Consequently, NDL undertook the analysis of both types. Several different types (e.g. cheese, pepperoni, pepperoni and sausage, and meat/vegetable combinations) and brands (e.g. major national brands and store brands) were purchased in supermarkets as described above. Later, several different types (e.g. cheese, pepperoni, and deluxe) of fast food restaurant pizza from major national chains were purchased from individual restaurants. For frozen pizzas, national composites of each type and brand were prepared. For the fast food restaurant pizzas, four composites of three randomly drawn samples of each type and brand were prepared.

The sampling plan was modified to meet the requirements of a specific study e.g. the sampling of drinking water in homes to analyze fluoride. It was also used for special population groups who may be located in geographically distinct areas (e.g. American Indians and Alaska Natives on reservations (Perry et al., 2002), and Hispanic Americans).

Foods were purchased under contract by a USDA-directed professional product pickup company using tested selection protocols in retail outlets. The foods were shipped to the Food Analysis Laboratory Control Center (FALCC) at Virginia Polytechnic Institute and State University in Blacksburg, Virginia for sample preparation. Procedures were developed for sample unit receipt, preparation, and storage which can be modified as needed for new food samples. FALCC continuously develops protocols for homogenizing and compositing samples based on instructions from NDL, collects relevant weights and dissection information for edible and non-edible portions as required, and documents processing and preparation procedures. Processed samples are shipped to qualified, analytical laboratories for analysis as directed by NDL. Reserve and archive samples of each food are maintained at FALCC.

2.4. Analyze sampled foods under USDA-supervised laboratory contracts

NDL employs a two-step process for awarding contracts for analysis of foods. The first step requires prospective contractors to submit a formal proposal. Prospective contractors are asked to include in their proposal a study plan that includes detailed plans and procedures for conducting the nutrient analysis of Key Foods, as well as identifying the analytical methods and procedures they will use to complete each task. The description of analytical methods includes sample handling, extraction or digestion, analysis, and quantification steps performed as part of the analysis. The laboratories propose specific analytical methods based on their expertise; the methods are examined by NDL during the review of the proposals. A detailed discussion of day-to-day quality control (QC) procedures is requested to facilitate the assessment of accuracy and precision for the unknown samples. The commercial laboratory proposals are evaluated by a panel consisting of NDL and other ARS staff members. The proposals received are scored according to how well the offerors have addressed the criteria delineated in the Request for proposals.

Those offerors whose proposals are deemed technically acceptable are sent "check" samples by FALCC for analysis. These are Certified Reference Materials (CRMs) procured from a variety of sources, both in the U.S. and internationally. Nutrient-specific analytical results generated by offerors for these samples are evaluated against acceptable ranges prepared by NDL. Offerors with the best written proposals and analytical results on the check samples may be awarded a contract for specific nutrients. Specific work orders under each contract are awarded such that contractors will not be given analytical work for nutrients where results for the check samples were outside the acceptable range.

Analyses of proximate components and most vitamin and minerals are typically performed at commercial laboratories. USDA agreements with universities or government laboratories (e.g. USDA's Food Composition Laboratory on flavonoids), have been established for other food components where specialized expertise is required. These include fluoride (Pehrsson et al., 2006), choline (Zeisel et al., 2003), vitamin K (Ferreira et al., 2006), folate (Phillips et al., 2005), vitamin E (Chun et al., 2006), proanthocyanidins (Gu et al., 2004), and flavonoids (Harnly et al., 2006).

Aliquots of each composite are sent to the laboratories by FALCC for analysis according to the work plans developed by NDL. Along with the samples, FALCC includes a QC material, which is either a control composite developed at FALCC or a CRM purchased from a certifying organization (Phillips et al., 2006). The laboratories are required to provide the results of their in-house quality control runs with the results for the analytical samples. The results from the laboratories are then reviewed by a quality control committee comprised of NDL and FALCC staff. The QC data for CRMs are compared to the certificate values for the material and the results for control composites are compared to a database of all results obtained for the particular control composites. Analytical data for food samples are compared to existing data for that food or a similar food. Questions are referred to the laboratories, and, if necessary, the analyses are repeated.

2.5. Compile newly generated data to update the National Nutrient Databank

The data from the analytical laboratories are then combined with the descriptive information collected on the sample units and are migrated to NDL Nutrient Databank System (NDBS), which NDL designed with three steps (Initial, Aggregated and Compiled) to manage and process food composition data. In the Initial step, all the individual data points are maintained along with full information on methods or analysis, analytical quality control, sample handling, common measures, and component and refuse data as well as the source and sampling information for each sample unit. Information is also retained on how individual sample units are composited. Values are converted to standard units of measure per 100 g, but the "as received" data values are also retained. In the Aggregated step, NDL scientists make decisions on how to group the data (e.g. combining data from different sources or a single source), weight data (usually by market share or production information), and/or handle new data when data already exist for a food item (i.e. replace the old data or combine it with new data). Specialized statistical procedures are used to aggregate the groups of data and generate descriptive statistics which take into consideration the grouping and nature of the data. NDL scientists also use statistical procedures within the NDBS to compare sets of data and test for outliers. For food items used in the FNDDS, missing data are imputed according to scientific principles (Schakel et al., 1998) at the Compiled step. If needed, missing values can be imputed using recipe or formulation modules within the NDBS. At this step, the name of the food item is finalized, common measures are selected and ranked, and the item is approved for release. Prior to release, the data are sent to experts for review; brand name items are sent to food companies or appropriate trade association, and other foods are sent to specialists familiar with the food and its nutrient content. The experts indicate if the data are acceptable based on their knowledge of the products and if any changes are needed. Once changes recommended by the reviewers are made, the data are disseminated in annual releases of the SR database. Current users can use each release to update the data on their computers and files.

3. Results and discussion

The current Key Foods list, based on NHANES 2003-04 data, contains 454 food items, which have been divided into quartiles based on weighted nutrient intake. The first quartile contains nine food items; the second, 25 food items; the third, 70 food items; and the fourth quartile, 350 food items. Since 1997, all of the food items in quartiles 1 and 2, most of those in the third quartile and many in the fourth quartile have been sampled and analyzed.

In many cases, a single food item was identified during generation of the Key Foods list, i.e. ranch style salad dressing. When an NDL survey of the marketplace showed that, in addition to the regular salad dressing, reduced-fat and fat-free varieties of the same type were also available, each was analyzed under NFNAP. In the case of pizza, which was described earlier, the items analyzed were expanded to include several types and brands of both frozen and fast food restaurant pizzas. Therefore, data are presented by brand name and as an aggregated item composed of all brands. This has resulted in an expanded number of pizza items ($n = 39$) in the database, giving the user the flexibility to better match the food item of interest to the analytical data generated under NFNAP.

These expansions have increased the number of foods sampled and analyzed under NFNAP beyond those included in the original Key Foods list. As a result, over 1200 unique food items have been analyzed since the inception of NFNAP. Over 700 of these foods (340 new foods and 360 updated or expanded foods) have been incorporated into SR19 or earlier releases, encompassing nearly 48,000 nutrient values. A summary of the foods analyzed to date is presented in Table 1. All data are released on the NDL web site: http://www.ars.usda.gov/nutrientdata.

3.1. Changes in nutrient values

The estimation of nutrient content for specific foods is a complex process and involves many variables. Over time, the measurement process has improved significantly, and the understanding of statistical sampling, sample handling, and quality control has expanded greatly. It is virtually impossible to separate or partition effects of any one factor from all the other factors that affect the final values. A few examples of changes in food composition values, observed by comparing data generated under NFNAP with that obtained previously, are described below.

Table 1
Number of foods samples analyzed under the National Food and Nutrient Analysis Program (NFNAP) by food type (1998–2006)

Food types	No. analyzed	Food types	No. analyzed
Dairy and eggs		Finfish and shellfish products	
Cheese	14	Finfish and products	12
Milk & butter	8	Shellfish	7
Eggs	5	Legumes and legume products	
Spices and herbs	30	Beans and peanuts	17
Baby foods	14	Soy products	25
Fats and oils		Baked products	
Shortenings and oils	17	Bread, rolls, bagels and tortillas	19
Margarine and spreads	24	Cookies and crackers	16
Dressings and mayonnaise	16	Pancakes and waffles	9
Poultry products		Cakes, muffins and donuts	14
Chicken	64	Pies and pastries	18
Turkey	2	Other	6
Organ meats	2	Sweets	
Soups, sauces, and gravies		Sweeteners and frostings	16
Soups	11	Candies	8
Sauces	3	Desserts	14
Gravies	2	Cereal grains and pasta	
Sausages and luncheon meats		Grains	62
Hot dogs and sausages	17	Pasta	7
Luncheon meats	15	Fast foods	
Breakfast cereals		Sandwiches and entrees	21
Ready-to-eat	30	Chicken	34
Cook and serve	17	Breakfast	19
Fruits and fruit juices		Pizza	30
Fruit	56	Side dishes	12
Juices	15	Beverages	16
Pork products	12	Meals, entrees, and side dishes	60
Vegetables and vegetable products		Snacks	27
Leaves	14	American Indian and Alaskan Native	
Roots	15	Alaskan Native	54
Potatoes	15	Apache	6
Other	47	Navajo	20
Nuts and seeds	15	Northern Plains	14
Beef products	35	Shoshone-Bannock	10
Beverages		Hispanic/Latino foods	17
Alcoholic	4	USDA commodities	53
Carbonated	7		
Other	66		

3.1.1. Vitamin A and individual carotenoids

Data on individual carotenoids were added to SR starting with Release 16 (issued in 2004). This permitted the calculation of total vitamin A from the individual carotenoids instead of total carotenes. This change allowed the calculation of Retinol Activity Equivalents (RAE), using new vitamin A activity factors recommended by the Institute of Medicine of the National Academies (IOM, 2001). In general, uses of the new factors resulted in moderate reductions of vitamin A activity for various foods. Some of the changes observed between SR12 (issued in 1999) and SR19 (NDL, 2006b) are presented in Table 2 and show the effects of calculations using the new vitamin A activity factors as well as the changes in the foods, better sampling, and improved analytical methodology. Of these, 2/3 increased and 1/3 decreased.

3.1.2. Fats and fatty acids

Current dietary guidance recommends reducing the amount of fat in the diet for the general population (DHHS and USDA, 2005). Accordingly, a number of commonly consumed foods which contain significant amounts of fat were selected for analysis as part of the NFNAP. Beginning with SR14 (issued in 2001), the statistical information presented along with the mean values were expanded to include upper and lower error bounds. These parameters could then be used as a method for detecting significant changes between the data sets. The upper and lower bounds were set at the 95% confidence level.

Comparing the nearly 48,000 nutrient values updated using NFNAP data, there are nearly 4000 values where the SR12 nutrient values are outside the range established by

Table 2
Changes in vitamin A and carotenoid content between Standard reference[a] (SR), Release 12 and SR, Release 19 for select foods

Food	Vitamin A (SR19) (RAE)	ß-carotene (μg/100 g)	α-carotene (μg/100 g)	ß-cryptoxanthin (μg/100 g)	Vitamin A (SR12) (RAE)	Change per common measure (RAE)	Common measure
Broccoli, raw	31	361	25	1	77	↓ 28	1 c, chopped (91 g)
Carrots, cooked	860	8332	3776	202	1227	↓169	1 carrot (46 g)
Peaches, raw	16	162	0	67	27	↓ 14	1 medium (150 g)
Peppers, red, cooked	275	2235	55	2071	188	↑ 59	1/2 c, chopped (59 g)
Spinach, raw	469	5626	0	0	336	↑ 40	1 c (30 g)
Sweet potatoes, boiled	787	9444	0	0	853	↓ 100	1 medium (151 g)

[a]Standard reference = National Nutrient Database for Standard Reference (NDL, 2006b).

Table 3
Changes in fat content between Standard Reference[a] (SR), Release 12 and SR, Release 19 for select foods

Food	SR19 (g/100 g)			SR12 (g/100 g)			% Difference (grams)	Change per common measure (grams)	Common measure (grams)
	Mean	N	Lower bound	Upper bound	Mean	N			
French fries, fast food	17.0	12	16.8	18.5	14.8	1	13	+3.02	1 medium (134 g)
Pizza, pepperoni, fast food	11.2	44	9.9	12.5	9.8	3	13	+1.54	1 slice (108 g)
Pizza, pepperoni, frozen	15.2	9	–	–	14.5	7	5	+0.80	1 slice (108 g)
Egg yolk, raw	26.5	12	26.0	27.1	30.9	33	16	−0.74	1 large (17 g)
Bacon, pan-fried	41.8	8	39.5	44.0	49.2	81	18	−1.79	3 slices (24 g)

[a]Standard reference = National Nutrient Database for Standard Reference (NDL, 2006b).

the lower and upper error bounds available in SR19 (NDL, 2006b). Some of the changes in fat content between SR12 and SR19 are presented in Table 3. For example, the SR12 total fat value for fast food French fries (14.8 g/100 g) was outside the error bounds established in SR19 (16.8–18.5 g/100 g) as was the total fat value for fast food pepperoni pizza in SR12 (14.5 g/100 g) when compared to the error bounds in SR19 (9.9–12.5 g/100 g). In these examples (Table 3), the number of samples may go down; however, the samples utilized in the calculation of the mean values represent national samples in place of those from more limited sources calculated for SR12.

3.1.3. Margarine and spreads

Another major source of fat in the diet includes various margarines and fat spreads. These products were targeted for analysis in NFNAP to better reflect the current fat levels and types available on the market. There are 57 types of margarines and spreads represented in SR19 compared to 26 in SR12. Data for a number of different fat levels are now available (including 80%, 70%, 60%, 40% fat levels and fat-free), as well as data for stick and tub forms. In addition, the more complete fatty acid profiles now includes up to 43 fatty acids and *trans* fatty acids.

With the addition of *trans* fatty acids to the Nutrition Facts panel in January 2006, many companies have reformulated their products to reduce or eliminate *trans* fatty acids. For example, a major fast food chicken company recently announced such a change (KFC, 2006) and, under the monitoring component of NFNAP, new samples of these foods will be procured and analyzed as funds permit. For this reason, a number of reformulated products including margarines, spreads, snack foods, and baked products were resampled during 2006. Preliminary results for margarines and spreads are presented in Table 4. However, there is an ongoing need to monitor the *trans* fatty acids content, along with that of other fatty acids, as manufacturers continue to reformulate these products when sources of high oleic/low linolenic acids become available in the marketplace.

Table 4
Changes in *trans* fatty acid levels for margarines

SR release	Type	*trans* fatty acids Mean ± SEM (*n*) (g/100 g)	Range (g/100 g)
Standard Reference, Release15 (issued in 2002)	Stick, 80% fat	19.69[a]	–
Preliminary data (2006)	Stick, 80% fat Tub, 80% fat	14.7 ± 0.83 (12) 4.52 ± 1.48 (11)	(11.2–18.8) (0.25–13.5)

[a]Calculated from sum of fatty acids.

3.1.4. Ground beef

Up to and including SR14 (issued in 2001), SR contained nutrient data for three types of ground beef—regular, lean, and extra lean, with fat levels ranging from 17% to 27%. However, these fat levels no longer reflected the products available in the market. With support from the National Cattleman's Beef Association, NDL scientists initiated a comprehensive analytical study designed to establish the mathematical relationship between the various nutrients and the total fat content of raw ground beef. Ground beef products were purchased nationwide; raw and cooked patties, loaves, and crumbles were prepared for chemical analyses. Because ground beef can be formulated to yield a variety of total fat levels, it was not possible to purchase ground beef samples at every fat level. Therefore, an integral part of the project was to take nutrient data generated by chemical analysis and analyze it using regression statistics. The regression analysis yielded equations which could be used to estimate nutrient profiles for products ranging from 5% to 30% fat. Nutrient profiles for raw and cooked ground beef products containing 5%, 10%, 15%, 20%, 25%, and 30% fat are currently available in SR. Because ground beef is available in the market with other fat levels, a computer program, callled the USDA Ground Beef Calculator, was developed to generate nutrient profiles for ground beef products containing any fat level between 5% and 30%. This program is now available on NDL's web site (NDL, 2006a).

4. Summary of NFNAP impact

Since the inception of NFNAP in 1997, over 1200 food items have been analyzed. Of these, over 700 food items (encompassing nearly 48,000 nutrient values) in SR have been updated or expanded using NFNAP data. This project was supported by a number of Institutes, Centers, and Offices of NIH, including the National Heart, Lung and Blood Institute and the National Cancer Institute. The National Center on Minority Health and Health Disparities along with the Indian Health Service provided support for the development of the American Indian/Alaskan Native Foods Database and the analysis of commodity foods. Other agencies in the Department of Health and Human Services such as the FDA and CDC also provided support. Several new components have been added to the database, including individual carotenoids, individual tocopherols, vitamin K, choline, fluoride, added vitamin E, and added vitamin B12. The choline research was funded by the NIH Office of Rare Diseases, and the fluoride database by the NIH National Institute of Dental and Craniofacial Research. Previously, the database contained only a total value for a class of compounds, such as total vitamin A or total carotenes; the database now contains data on the individual carotenoids. At the time NFNAP started, many of the fatty acid profiles were imputed or based on limited data. Today, many of those profiles have been updated using NFNAP data and are provided for the FNDDS. A number of these changes have been made in response to recommendations by the Institute of Medicine in several reports on Dietary Reference Intakes (DRI) (IOM, 2001). These include adding dietary folate equivalents along with food folate and folic acid, supplementing the total folate which previously was the only form of folate included in the database (IOM, 1998). Other changes include replacement of α-tocopherol equivalents with α-tocopherol and replacing Retinol Equivalents with Retinol Activity Equivalents, as described earlier. These reports also serve as guidelines for future research and database expansion. The NDL analytical program provided the strategy and support to generate new analytical data to permit these changes to the database.

A series of Special Interest Databases have been generated under NFNAP and are listed in Table 5. The values from the database on individual carotenoids and fluoride, as well as the total choline and betaine values from the database on choline have been incorporated into SR. These databases provide researchers with composition data on various bioactive compounds, such as isoflavones, flavonoids, and proanthocyanidins, which can be used to ascertain the role of these compounds in the prevention of various chronic diseases.

NFNAP data have also allowed USDA nutrient databases to keep up with the dynamic national food supply, adding new foods as manufacturers expand product lines to meet consumer demands for foods that are free, low, and reduced in fat, sugar, calories, and other food components. Data generated under NFNAP have permitted the replacement of many imputed or calculated values with analytical values. The adoption of statistically valid sampling plans has resulted in nationally representative data and the plans are easily adaptable to fit the unique characteristics of foods and nutrients. In a number of cases, the sampling and analytical plans have been modified to collect additional data, which will permit the analysis of variability between samples.

Data generated by NFNAP support a number of key public health programs and the development of a variety of nutrition policies and programs such as the DRIs and the Dietary Guidelines for Americans. Data are also used by researchers at universities and government agencies in the U.S. and worldwide in a wide variety of health and nutrition studies. The food industry uses these data as part of their nutrition labeling programs as well as for other research and development activities. Finally, the data are used by consumers, who are increasingly interested in what is in the foods they eat and how it might affect their health and well being.

Table 5
Components included in NFNAP-generated special interest databases

Database	Year	No. items	Compounds
Carotenoids[a]	1998	206	α-carotene, β-carotene, β-cryptoxanthin, lycopene, lutein + zeaxanthin
Isoflavones (NDL and ISU, 2002)	2002	128	Genistein, daidzein, glycitein
Flavonoids, Release 1.0	2003	225	Flavonols, flavones, flavanones, flavan-3-ols, anthocyanidins
Flavonoids, Release 2.1 (NDL, 2007)	2007	396	
Proanthocyanidins (NDL, 2004b)	2004	205	Mono- thru polymers of flavan-3-ols
Choline (NDL, 2004a)	2004	434	Betaine[b], total choline[b], phospho-, lycerophospho-, phosphotidyl choline, sphingomyelin, free choline
Fluoride[b], Release 1.0	2004	400	Fluoride
Fluoride[b], Release 2.0 (NDL, 2005)	2005	427	

[a]Added to Standard Reference, Release 16.
[b]Added to Standard Reference, Release 19.

5. Future plans

In 2005, NFNAP in cooperation with NIH was renewed for five additional years. At the same time, the NIH National Cancer Institute assumed the coordination role of the USDA-NIH Interagency Agreement. The new proposal leveraged the infrastructure which had been developed earlier and identified five principal areas of research: (1) monitor Key Foods, (2) conduct comprehensive analyses of selected Key Foods, (3) develop ethnic foods databases, (4) generate data for new nutrients/bioactive food components, and (5) develop validated ingredient database for dietary supplements.

The Nutrient Data Laboratory will continue to update, revise and expand its nutrient database products as well as analyze changes and variability in nutrients. The NFNAP is an integral part of this effort and its continued funding is essential to its success.

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