Emerging Issues for the Next Generation of Databases

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Foreword

Keynote Address
Food-Based Dietary Guidance
Janet King, USDA, ARS, Western Human Nutrition Res. Ctr. San Francisco

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  Bernadette Marriott, NIH, Director, Office of Dietary Supplements
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Capstone Speaker
Emerging Issues for the Next Generation of Databases
Jean Pennington, NIH, Division of Nutrition Research Coordination

Poster Abstracts

The USDA National Nutrient Databank

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The USDA National Nutrient Databank provides the basis of virtually all U.S. and many other national and international food composition databases. Data are provided for almost 6,000 foods and over 80 components. Data are obtained from analyses of foods as well as by calculation and imputation from values for related foods. Data documentation are provided in English and include scientific names for plant and animal products. INFOODS tagnames for food components are included as well. The Nutrient Data Laboratory (NDL) is redesigning the hardware and software used to manage the data to provide a state of the art database environment. USDA has also developed a new plan for generating new analytical data for 1000 core foods and ingredients. These data are also used to develop representative estimates for other foods, including multi-component foods. The NDL is committed to providing current and representative data for foods, including many new components of interest to the public health community. To accomplish this goal NDL staff will implement data evaluation criteria to assure data quality, will validate data calculation procedures, and will support research on the identification of data needs. As part of the NORAM FOODS Regional center NDL will increase communication with Regional partners and will support training and research needs.

DATABASES FOR FLAVONOIDS AND PHYTOESTROGENS.

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Flavonoids and phytoestrogens are two of several classes of phytonutrients which have been shown to have important biological activities relative to human health. Over four thousand flavonoids have been identified and characterized in nature, primarily in the plant kingdom. Fortunately for those of us working in the field of food composition, only a small percentage of this number are prominent in the foods we commonly consume. There are six subclasses of flavonoids ranging from anthocyanidins to flavonols. Within each subclass there are two to five basic (aglycones) flavonoids which are prominent in the foods we eat. The data on the flavonoid content of foods is very limited. Most have been generated as part of horticultural or food science studies which have investigated only one or two subclasses of flavonoids in a particular fruit, vegetable or other food. We have formed a collaboration with scientists at the USDA Nutrient Data Laboratory as well as at Tufts University to collect the available food flavonoid data and assemble it into a database of values which will be made available on the Internet.

Microbial action in the gastrointestinal tract produces compounds with estrogenic activity (phytoestrogens) primarily from two classes of phytonutrients, isoflavones and lignans. Isoflavones, characterized by daidzein, genistein, glycitein and their conjugates, are found primarily in soybeans and soy-based foods. Several laboratories have developed analytical procedures for measuring these compounds in foods. We have been collaborating with one of these laboratories, Dr. Patricia Murphy at Iowa State University, to measure the concentrations of isoflavones in a variety of soy-foods sampled in several metropolitan areas of the U.S. In addition we have extended our collaboration to include scientists at the USDA Nutrient Data Laboratory who are collecting published data on the isoflavone levels of soybeans and soy-foods. These data will be combined with the analytical data from Dr. Murphy's laboratory to form an isoflavone database which will be available on the Internet during mid-1998.

Although over four hundred lignans have been identified and characterized in nature, only two, secoisolariciresinol (Seco) and matairesinol (Mati), appear to be precursors to compounds with estrogenic activity. These phytonutrients are prevelant in flaxseed meal, rye flour and selected other oil seeds, and to a lesser extent in cereal brans, whole cereals and legumes. The currently available analytical procedures to measure Serco and Mati in foods are very laborious. As a result, we are conducting research to develop simplified techniques so that these important phytonutrients can be quantified in commonly consumed foods and appropriate databases subsequently assembled.

UPDATE OF THE CAROTENOID DATABASE FOR FOODS

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Abstract

Traditionally only total vitamin A has been reported in food composition tables, either as International Units or Retinol Equivalents. However, during the last decade, there has been a growing interest in various food carotenoids and their possible link to chronic diseases. In 1993 the USDA-NCI Carotenoid Database containing values for five individual carotenoids was released. A collaborative effort between the USDA, Nutrition Coordinating Center and Medical College of Virginia has resulted in an updated version of the database. Data on the carotenoid content were evaluated using an expert system developed by USDA scientists. The procedures used in the 1993 database were slightly modified to accommodate recent developments in analytical methodology as well as changes in criteria for sampling plans and numbers of samples. Values for " - and $-carotene, lutein+zeaxanthin, lycopene and $-cryptoxanthin from approximately 190 new references were evaluated. Samples of more than 50 foods, including various multicomponent entrees, were obtained from three cities nationwide and the foods analyzed for the above carotenoids. The result was a new database that incorporated previous data, new acceptable literature values, and the analytical data, to yield a database of approximately 200 foods, including different forms of these foods. Mean values, ranges, standard errors, numbers of studies, and confidence codes are reported in the database for each food for the carotenoids listed above. In addition zeaxanthin values are presented for 23 foods. USDA NDB numbers were assigned to facilitate the use of carotenoid data with other USDA food composition data. Supported in part by NCI grant RO1-CXA59791.

Introduction

At one time, individual carotenoids were looked at only as precursors to vitamin A, not having any biological importance of their own. Today they are revealed as antioxidants which may protect against the development of selected diseases. Their role is hypothesized as preventing or minimizing free radical damage associated with cancer (Ziegler, 1991), coronary heart disease (Gerster, 1991), cataracts, and age-related macular degeneration (Snodderly, 1995). The National Academy of Sciences has convened a panel to look at developing Dietary Reference Intakes for carotenoids. They first met this past February and their final report is due in the fall of 1999.

Background

Fruits and vegetables are major contributors of carotenoids in human diets. Carotenoids are one category or class of compounds found in fruits and vegetables which have stimulated a great deal of interest among health researchers . The USDA/DDHS Dietary Guidelines for Americans (1995) recommends increased consumption of fruits and vegetables. Programs such as the National Cancer Institute's Five-A-Day program also recommend consuming more fruits and vegetables. Reliable databases for carotenoids are needed to conduct epidemiological studies to study an association between dietary intake of particular carotenoids and the risk of certain diseases. The first USDA database for carotenoids in foods was published by Mangels *et al* (1993) as a result of the evaluation of the published analytic data. An artificial intelligence system was used to generate a database of 120 fruits and vegetables. At that time more than 180 articles published from 1971 to 1991 were reviewed. West and Poortvliet (1993) have also generated a database for carotenoid contents of foods with special reference to developing countries.

In view of continuing interest in individual carotenoids, further development of these databases was needed to improve the reliability of the carotenoid values and to expand the database to include values for high fat foods. The improvements in analytical methods, particularly the use of HPLC for separation and quantification, and also sample handling and extraction procedures have added to the amount of data on individual carotenoids.

A grant application was submitted to the National Cancer Institute to collect and evaluate new reports of carotenoids since the 1993 release of the USDA-NCI carotenoid database. The principal investigators and research team for this project are listed in Table 1.

The grant proposal called for the development of an updated carotenoid database, but also the improvement of analytical methods for high-fat foods, such as butter, margarine, and cheeses, which will be reported in a future article; and the inclusion of more mixed dishes. The carotenoids covered are " -carotene, $-carotene, lutein+zeaxanthin, lycopene, and $-cryptoxanthin. A two pronged approach was used to develop the new database: 1) analyses at USDA's Food Composition Laboratory based on nationwide sampling; and 2) a review of literature published since the 1993 table.

Table 1 - Research Team

Principal Investigators:

Gary Beecher

I. Marilyn Buzzard

Joanne Holden

Team Members:

Beltsville Human Nutrition Research Center

Seema Bhagwat

Carole Davis

Susan Gebhardt

David Haytowitz

Chris Spangler

Denise Trainer

Nutrition Coordinating Ctr., University of Minnesota

Alison L. Eldridge (now at Procter & Gamble)

Sally Schakel

Analytical Work

Ten fruits, 23 vegetables, 14 mixed dishes, 3 dairy products, selected margarines, eggs, and corn meal were selected based on their contribution of individual carotenoids to the diet. A sampling plan was developed for each item. Samples were collected from different sources in three major metropolitan areas of the U.S. For the fruits, vegetables, dairy products, eggs, and corn meal, growing location and seasonal variation, were considered in the development of the sampling plan. For the processed products (mixed dishes and margarine) brand predominance and distribution patterns were considered. For example, if one brand item was manufactured in only one plant, the product was collected from several sources and composited. In most cases, analyses were done by brand, which were composited by city. For some products, nationwide composites were prepared and analyzed. Results from the analytical portion of this project were then entered into the database using the expert system described below.

Literature Search and Data Evaluation

Research published in national and international journals since 1992 was reviewed using the expert system developed by USDA. This system evaluates analytical values for method of analysis, analytical quality control, number of samples, sample handling,

and sampling plan. Data for each food and nutrient are rated on a scale of 0 to 3 with 3 representing the optimum score for each evaluation category. The criteria needed to get the highest score for each category are as follows: methods must be documented, validated for the foods analyzed and reference materials used with results within an acceptable range; analytical quality controls must be documented and optimum accuracy and precision of methods must be obtained; number of samples must be 10 or higher with standard deviation, standard error or individual values reported; complete documentation of the sample handling procedures, including validation of homogenization, detailed description of food preparation procedures, and monitoring of storage and moisture changes must be reported; and multiple geographic sampling, representative of brands/varieties consumed with complete descriptions, is also required. Results from analytical contracts sponsored by USDA to add values to the USDA Nutrient Database for Standard Reference were also included in this review.

Analytical methods consist of several steps including sample processing, and carotenoid separation, identification and quantification. Validation of the method by using a reference material, or good recoveries with an internal standard, or good agreement with another valid method or laboratory is also very important. The studies which used only the AOAC method for the separation were not included in the evaluation since the AOAC method alone does not separate individual carotenoids; however used in conjunction with other separation methods it can he utilized effectively. Some of the studies which used the AOAC method with modified separation procedures and also extensive identification procedures were included for the data evaluation.

Developing the Tables

In the 1993 release, different forms of a single food (e.g., raw, cooked, canned, etc.) with similar values were aggregated, and median values were presented. In the new version, food forms are disaggregated to be consistent with the USDA Nutrient Database codes for food names/descriptions. Data for U.S. and non-U.S. foods were separated. The U.S. foods were defined as those consumed in the United States. Acceptable data for U.S. foods were combined to generate mean values. Data for non-U.S. foods will be finalized and released at a later date.

A Quality Index (QI), the mean of the five ratings for the evaluation categories, was calculated to indicate the overall data quality for the particular carotenoid in a specific food and source. If the rating for the analytical method was zero or if three of the five ratings were zero, the Quality Index for that value became zero. QIs for foods with similar descriptions were summed and a confidence code (CC) of a, b or c assigned to each value (Table 2). The Confidence Code is an indicator of relative quality of the data and the confidence a user can have in each mean.

Table 2. Assignment and Meaning of Confidence Codes

Sum of Quality Indices	Confidence Code	Meaning of Confidence Codes
> 6.0	a	The user can have considerable confidence in this value
3.4 - 6.0	b	The user can have confidence in this value; however, problems exist regarding the data on which the value is based
1.0 to < 3.4	c	The user can have less confidence in this value due to limited quantity and/or quality of the data

Carotenoid values were expressed as means instead of medians as reported in the earlier database as a result of the consensus reached during a USDA Statistical Workshop organized by the principal investigators in April 1996. During aggregations, carotenoid values from each reference/study were weighted by their respective sampling plan ratings, which had been assigned during the data evaluation process. Sampling plan reflects the representativeness of the sample regarding the brand or cultivar, method of preparation and the geographic origin. The higher rating for sampling plan indicates the national representativeness for that particular food. Lower ratings were assigned to data for foods which were sampled in a more limited way or which were grown in experimental conditions or small regional production facilities. Therefore mean values derived more weight from those values which were more representative of the food supply.

The total number of means/individual values (indicated by #S) used to compute the data in the Carotenoid Database was included rather than the total number of samples analyzed. In the scientific literature each value can be a mean of many values (depending on the number of samples used in the study) or an individual value. Furthermore there may be more than one value for a single food in one reference. As a result, the total number of references may not equal #S. Since the data have been compiled from various sources, #S does not necessarily equal "n" in statistical terms.

The definition of number of samples was clarified to differentiate between the number of sample units purchased and the number of samples analyzed. The replicate values for the same laboratory sample were counted as part of the same sample.

The completed database contains 3 files:

1. Car_tble (carotenoid_table) is the table of analytical carotenoid values.
2. Car_ref (carotenoid_references) is a list of references/studies from which carotenoid values were obtained.
3. Zea_tble (zeaxanthin_table) contains a table of zeaxanthin values and references for 23 selected foods.

Car_tble - Carotenoid Table

This table contains the actual values generated as part of this project. The attributes are given in Table 3:

Table 3. Attributes of the Carotenoid Table

Attribute	Description	
NDB	USDA Nutrient Data Bank Number	
Desc	Food Description	
Carot	Name of the carotenoid	
	a_car	" -Carotene
	b_car	$-Carotene
	b_cryp	$-Cryptoxanthin
	lut+zea	Lutein+Zeaxanthin
	lyc	Lycopene
Mean	Mean value (mcg/100g, edible portion)	
SEM	Standard error of the mean	
#S	Number of means/individual values	
Min	Minimum Value (mcg/100g, edible portion)	
Max	Maximum Value (mcg/100g, edible portion)	
CC	Confidence Codes	
Ref. No.	Reference(s) from which carotenoid values were obtained	

The NDB number is a five digit numerical code used in the USDA Nutrient Database for Standard Reference, the electronic version of Agriculture Handbook No. 8. This number also corresponds to one of the codes used to designate foods as ingredients in the Recipe File for the USDA Nutrient Database for Individual Food Intake Surveys and can be used to update calculated carotenoid values for those multi-component foods

containing fruits and vegetables. Items in this table, which do not have corresponding entries in the USDA Nutrient Database for Standard Reference, are indicated by 'xxxxx' in the NDB No. Column. The USDA Database for Standard Reference can be downloaded from the USDA Nutrient Data Laboratory's (NDL) Home Page.

The Confidence Code (CC) designated as a, b, or c is a general indicator of the quality of the data (a=most confidence). It was determined using the expert system described above.

The references used to generate each value in the table are given in the "Ref. No." fields. This number links directly to the Carotenoid References list.

Car ref- Carotenoid References

A complete list of the 49 references used to create the USDA-NCC Carotenoid Database is provided. In addition to the usual information (authors, title, and journal citation), a brief description of the analytical method used and carotenoids analyzed is included along with the list of references.

Zea_tble - Zeaxanthin values

A separate table is included for zeaxanthin values for 23 U.S. foods. As there are very limited data for the zeaxanthin content of foods, a single value from a reference constitutes the 'mean', the SEM (standard error of the mean) could not be calculated, and a confidence code was not assigned. The references for this table are also included in the "Car_ref" file.

The result is a database with 215 food items, containing up to 5 carotenoids. The database will be available on the NDL Home Page: http://www.nal.usda.gov/fnic/foodcomp. It will be accessible online and you will be able to either view it on your monitor or download a compressed file, containing the database files which can be used with your database program.

Future

In the future the carotenoid database will become part of the USDA Nutrient Database for Standard Reference. As this new carotenoid database replaces the database released in 1993, it in turn will be replaced by another, newer database in the future. The Nutrient Data Laboratory in cooperation with the National Heart Lung and Blood Institute has begun the National Food and Nutrient Analysis Program which is described elsewhere in the proceedings by Joanne Holden. This new program gives us the resources to analyze foods identified by this project as needing additional data on carotenoids. For example, carrots have long been know to have large amounts of

$-carotene and we have identified a number of sources of data for this food. However, carrots in their various forms (raw, cooked, canned, frozen) contribute approximately 1/3 of vitamin A to the diet as identified by our Key Foods approach. Clearly, we need to develop a nationwide representative sample for carrots, so that intake can be accurately assessed.

The carotenoid content of foods is highly variable due to a number of factors, such as growing areas, cultivars, processing techniques, lengths and conditions of storage, and possibly different methods of analysis. The data were obtained from many sources and may represent different growing years. All of these factors contribute to the variability in carotenoid content of foods. Analysis of nationwide samples of the key contributors of carotenoids to the diet will allow us to better understand the sources of this variability.

The Nutrition Coordinating Center (NCC) at the University of Minnesota also develops and maintains a nutrient database used for clinical diets and epidemiological studies that is derived from the USDA Nutrient Database for Standard Reference. The data developed in this project will also be added to the NCC database. In creating the 1993 carotenoid database, values were calculated for carotenoid containing items in the Survey Nutrient Database. NCC and NDL will work together to impute carotenoid values for items in the primary nutrient database (PDS) so that carotenoid values can be calculated for many multi-component foods. These foods make a significant contribution of carotenoids to dietary intakes. Ultimately, using new analytical values and imputed values, carotenoids will be added to future releases of the USDA Nutrient Database for Standard Reference. In time these data and others will be used to add carotenoids to the PDS so that carotenoid data can be used with food consumption survey data collected by USDA's Continuing Survey of Food Intakes by Individuals (CSFII) and DHHS' National Health and Nutrition Examination Survey (NHANES).

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USDA'S FOOD PYRAMID SERVINGS DATABASE

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The Food Guide Pyramid translates information on nutrient needs into food-based servings recommendations. It is the primary tool used by U.S. nutritionists to describe a healthful diet. However, dietary assessments have generally focused on the adequacy of nutrient rather than food intakes. One reason is that food composition databases have not been available with information on food components defined in terms comparable to food servings.

ARS has developed a Pyramid Servings Database, which makes it possible to compare food intake data to pyramid recommendations. This database was developed using a new method that separates foods into ingredients before servings are counted, adheres to pyramid principles, uses the serving sizes specified by the pyramid, and categorizes foods according to pyramid criteria. It includes data on numbers of servings of 30 food groups per 100 grams for approximately 6,000 foods -- all those reported in USDA's 1994-96 Continuing Survey of Food Intakes by Individuals (CSFII). The 30 food groups include the major pyramid food groups (grains, vegetables, fruits, dairy, and meat and meat alternates), selected subgroups, and three components from the pyramid tip -- fat, sugars, and alcohol. Data for the grain, vegetable, fruit, and dairy food groups are in servings. Data for the meat and meat alternate food groups are in ounces of cooked lean meat equivalents. Fat from the pyramid tip is in grams, added sugars are in teaspoons, and alcohol is in number of drinks.

The Pyramid Servings Database represents an important dietary assessment advance. Pyramid Intake Data Files for the 1994-96 CSFII have been created using this new database. These files have been used to assess the adequacy of the American diet relative to Food Guide Pyramid recommendations and to monitor progress toward national nutrition objectives.

Data from the CSFII 1994-96 for over 14,000 individuals aged 2 years and over were used to estimate mean numbers of servings from pyramid food groups and percentages of the population meeting pyramid recommendations. In 1994-96, the average American diet had fewer servings from the fruit, dairy, and meat groups than minimum numbers recommended; numbers from the grain and vegetable groups were near the bottom of recommended ranges. Intakes of whole grains, dark-green vegetables, and legumes were notably low. Large proportions of the population (59%-77%) failed to meet food group recommendations, and intakes of fat and added sugars exceeded recommendations.

The Pyramid Servings Database and Pyramid Intake Data Files for CSFII 1994-96 are available on CD-ROM for $65 from the National Technical Information Service at 5285 Port Royal Road, Springfield, VA 22161 (Phone 703-605-6000). Request NTIS Accession No. PB98-500457.

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Dietary Supplement Databases— Information from NHANES III and Plans for Future NHANES Database

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Abstract

The third National Health and Nutrition Examination Survey (NHANES III), 1988-1994, included household interview and health examination components. NCHS released questionnaire and examination data files in July, 1997; the data included household interview information on vitamin and mineral supplement use and 24-hr dietary recall data from the dietary interview component of the health examination. The NHANES III dietary supplements database will be part of a second NHANES III data release in the Spring of 1998. Information on more than 2,400 prescription and nonprescription dietary supplements is included in the NHANES III database.

All vitamin and mineral supplement use information was collected in the respondents' homes by trained household interviewers. The focus of the data collection was on vitamins and mineral products, but other products including herbal products and botanicals were reported; information on herbal products and botanicals was included in the NHANES III dietary supplements data file. Whenever possible, the actual supplement product containers were observed by the interviewers so that complete and accurate information about the products could be recorded. The product name, manufacturer, usual dosage, frequency of use, and duration of use was recorded for each product. Nutrient/ingredient composition data was not recorded during the actual interview. More than 30% of the NHANES III interviewed sample 2 months of age and older took at least one vitamin-mineral supplement during the month prior to the household interview.

NCHS staff compiled the NHANES III supplements database using information that was provided by manufacturers or researched by checking labels, *The Physician's Desk Reference,* and other resources. NCHS developed criteria for coding all default products; these criteria were used when complete information was not obtained during the interview. The database is comprised of two primary tables; "SUPLIDEN" contains product identifier information--a standardized product name, product type code, numeric product identification code, a source of information code, and a dosage form code. The second table, "SUPLCONC", contains the ingredient and nutrient composition information for each product.

The supplement data, together with information that was collected during the dietary interview is being used to estimate total nutrient intakes from foods and supplement products by the U.S. population 2 months of age and older between 1988 and 1994. The supplement data provide interpretive information for other components of the

survey such as the laboratory component which includes extensive nutritional biochemistry and hematological data. This database will support research aimed at studying the effects of dietary supplements on the health and nutritional status of the U.S. population, and provides important baseline information for future NHANES.

Introduction

Health and Nutrition Examination Surveys (HANES) are periodic surveys that are conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention. Data are obtained through personal interviews and health examinations. NHANES data are used to estimate the prevalence of selected diseases and health risk factors in the U.S. population including the prevalence of overweight, high blood pressure, and elevated serum lipids. National reference values for nutrition and health parameters including food energy and nutrient intakes from dietary sources, nutritional biochemistry values, and body measurement data are produced from NHANES data. NHANES data are also used to examine secular trends in the prevalences of diseases and health risk factors, and to study the etiology of chronic and infectious diseases in the U.S. population.

Three national HANES (termed “NHANES”) were completed between 1971 and 1994: NHANES I (1971-75); NHANES II (1976-80); NHANES III (1988-94). Hispanic HANES, a special survey of three Hispanic subgroups, was conducted from 1982-84 to provide comprehensive health and nutrition data on three major Hispanic subgroups living in the United States: Mexican Americans living in the southwest U.S., Cuban Americans in Dade County, FL, and Puerto Ricans in the New York City metropolitan area. The most recent survey, NHANES III, 1988-94, was conducted in two phases. Each three-year phase, as well as the entire 6 years constituted a national sample.

The NHANES III sample design, interview and examination components, survey methods, and protocols were described in proceedings from the 1989-96 National Nutrient Databank Conferences. NCHS published a survey manual in 1994 entitled, Plan and Operation of the Third National Health and Nutrition Examination Survey, 1988-94 which describes the overall design, methodology, and content of the Survey (1). NCHS released the NHANES III data files in July, 1997; included with the files are provisional household information on vitamin and mineral supplement use from the household interview and 24-hr dietary recall data from the dietary interview component of the health examination (2). The second NHANES III data release scheduled, for April 1998, includes the final data on vitamin and mineral supplement use and the dietary supplements concentration database; the common link between the questionnaire and supplement products and concentration database is the product identification code. The database includes information on more than 2,400 prescription and nonprescription dietary supplements that were reported during NHANES III. An overview of the data collection methodology and coding for supplements follows.

Data Collection Methods

The NHANES surveys are comprised of two components: a household interview and a health examination. Household interviews were conducted in respondents' homes by trained, bilingual (in English and Spanish) interviewers. During the NHANES III household interview, respondents were asked if they had used or taken any prescription or nonprescription vitamin and mineral supplements during the month prior to the interview. (Note: Information was also obtained on the use of other prescription medications, antacids, and nonprescription pain medications.) All supplement information was recorded electronically by means of a computer-assisted personal interview (CAPI) system. Whenever possible, the interviewers observed the actual supplement product containers in order to record complete and accurate information about the products. The product name, manufacturer, usual dosage, frequency of use, and duration of use was recorded for each product. Nutrient or ingredient composition data was not recorded during the interview due to time constraints.

The focus of the NHANES III supplement questions was vitamins and mineral products, but respondents reported other products including herbal products and botanicals. Information on herbal products and botanicals was included in the NHANES III dietary supplements file, but since they were not part of the standard interview question, these data should not be considered to be nationally representative. The NHANES III data revealed that supplement use is widespread in the U.S.; supplement products were taken by more than 30% of the NHANES III interviewed sample 2 months of age and older. The task of reviewing, researching, and coding these products required the development of coding guidelines and data editing specifications.

At the time the data were reviewed and coded, there were no current, comprehensive databases available on dietary supplements products that would meet NCHS's needs. NCHS compiled information from manufacturers and product distributors, product labels, and references including The Physician's Desk Reference. Complete information was not available for all products that were reported; NCHS developed default coding criteria for several categories of supplement products. NCHS staff compiled the information for the individual product records and database files.

The NHANES III Supplements Database

The NHANES III database consists of two look-up files that are linked to the questionnaire information on each product reported; the common link between the questionnaire and the supplements database is the product code. A look-up file called "SUPLIDEN" contains descriptive information about each product, including the standardized product name, product type code, product identification code, a source of information code, and a form code indicating the dosage on which the nutrient or ingredient values are expressed in the database. The standardized dietary supplement

name was coded based on the name and other information recorded during the interview, or a default product name as assigned when the information did not permit NCHS to match the product to an actual brand name or private label product. Approximately 12 percent of the supplements in the database are default products. Default product names are identified in the file. The 6-digit product identification code is the common link between the questionnaire data, the product description table (SUPLIDEN), and the nutrients and ingredients table (SUPLCONC). The product identification codes are product-specific and manufacturer/distributor-specific. The first three digits represent the manufacturer or distributor, and the last three digits represent a specific product produced by the manufacturer or distributor. In general, default products begin with three 8's since the manufacturer or distributor is unknown.

The second look-up file, “SUPLCONC”, contains the ingredient and nutrient composition information for each product. The nutrient names include vitamins and minerals such as niacin and iron as well as more unusual ingredients such as dong quai and kelp. NCHS ranked the sources of information that were used to assign nutrient or ingredient values according to their perceived validity and currency of the values. The preferred source of information, if it was available, was the manufacturer or distributor. When this was not available, either product labels or packages, catalogs, or published references were used. Some nutrient data were estimated or inferred from product names. Estimation was used to assign nutrient or ingredient values to brand name products and for most default products; the estimated values were based on information that was compiled for similar products. Inference was used for single ingredient products where the concentration was implied in the name.

Uses of Supplement Data

The supplement database and questionnaire information have important monitoring and research applications. The intake estimates for vitamins and minerals, together with information that was collected during the 24-hour dietary recall interview, are useful to estimate total nutrient intakes from foods and supplement products by the U.S. population 2 months of age and older between 1988 and 1994. This information is not available from previous NHANES or other national food consumption surveys. Total nutrient intakes are needed to assess the contribution of “diet” to nutritional status. Second, the supplement data provide interpretive information for the laboratory and clinical components of the survey including the nutritional biochemistry, hematological data, and possibly other components such as bone densitometry and blood pressure levels. For example, it is necessary to identify supplement users when interpreting hemoglobin and ferritin data to estimate the prevalence of iron deficiency anemia. Similarly, information about supplement use practices is useful when reviewing serum folate and red blood cell folate data in assessments of folate nutritional status.

Finally, many potential health effects of dietary supplements are unclear due to a lack of qualitative and quantitative data on supplement use. The Third Report on Nutrition Monitoring in the United States noted that the lack of product-specific information on vitamin and mineral supplement products limited efforts to assess excessive nutrient intakes from all sources (3). Further, The Report of the Commission on Dietary Supplement Labels (4) cited the need for research to explore the health effects of supplement use; such research should include vitamin and mineral supplements as well as botanicals and other products that are used as dietary supplements. The NHANES III database is useful for this type of research and provides baseline information to track dietary supplement use in future NHANES.

NCHS will build on information that was obtained on dietary supplements during NHANES III. Final preparations are underway for NHANES to become a continuous, annual survey program beginning in early 1999. NCHS solicited input and received many recommendations for the dietary supplement component of the survey. A 1-day workshop, sponsored by NCHS, was held in August, 1997 to identify the uses of dietary supplement information and potential sources of information for future dietary supplement databases, including the databases by the NHANES program. The attendees included Federal agency and dietary supplement trade association representatives. Since the workshop, NCHS has pursued plans to expand the scope of the NHANES dietary supplement component to include all dietary supplements, including herbal products and botanicals. NCHS anticipates that many of the products that were reported during NHANES III are likely to be reported again; the NHANES III database content will be reviewed and updated as needed. Household interviewers will have online lists of dietary supplements and medications available at the time of the interview to make data collection more efficient. The plans for future NHANES include enhanced product research capabilities, and timely interview data review, coding, and reporting.

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NATIONAL FOOD AND NUTRIENT ANALYSIS PROGRAM

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Abstract

The National Food and Nutrient Analysis Program (NFNAP) is a research program that is designed to achieve long-sought improvements to the National Nutrient Data Bank through a comprehensive revision of scientific concept and technical approach. The project was begun in FY97 with the support of the National Heart, Lung, and Blood Institute, NIH and various other agencies and oversight by the Nutrient Data Laboratory, Agricultural Research Service, USDA. Research activities comprise four linked components, or Specific Aims:

1) Evaluate existing data for scientific quality;
2) Identify Key Foods and Nutrients for sampling and analysis plans;
3) Devise and implement a probability-based sampling survey of U.S. foods; and
4) Analyze sampled foods under USDA-supervised laboratory contracts.

The outcome of the program will be a body of nutrient data with unprecedented analytical quality for 1000 Key Foods and ingredients. The plan will yield unbiased estimates for the mean and variability of nutrient content in high priority foods, and the data will be statistically representative of both the national food supply and national food consumption patterns. It thus will be possible to use the NFNAP data with a high level of confidence that can be expected to benefit essentially every activity touching on human nutrition research, education, and policy.
Each Specific Aim (SA) comprises a major activity within an integrated research program that takes advantage of the results of national food consumption surveys; recent advances in sampling statistics, data evaluation methodology, and analytical chemistry; and information on product alterations in the national food supply. The data yielded by each phase of the program will become an inherent part of the new USDA National Nutrient Databank System. Better estimates of the mean nutrient content of foods will allow individuals to be more accurately classified according to nutrient intake. This will improve our ability to detect etiologic relationships; delineate biologic mechanisms; assess time trends in nutrient intake; and define populations at nutritional risk. Better estimates of the variability in nutrient content will allow foods to be more rationally classified and grouped. This will improve our ability to monitor the nutritional adequacy of the food supply; develop intake methodology based on categorization of foods; design dietary guidance for the healthy; and plan therapeutic diets for the sick.

I. Summary

The National Food and Nutrient Analysis Program (NFNAP) is a research program that will achieve long-sought improvements to the National Nutrient Data Base through a comprehensive revision of scientific concept and technical approach. The project is directed by the Nutrient Data Laboratory, Agricultural Research Service, USDA.

Research activities comprise four linked components, or Specific Aims:

1) Evaluate existing data for scientific quality;
2) Identify Key Foods and Nutrients for sampling and analysis plans;
3) Devise and implement a probability-based sampling survey of U.S. foods; and
4) Analyze sampled foods under USDA-supervised laboratory contracts.

The outcome of the program will be a body of nutrient data with unprecedented analytical quality. The data will be statistically representative of the national food supply and of national food consumption patterns, and will provide unbiased estimates for the mean and variance of nutrient content in high priority foods. It thus will be possible to use the NFNAP data with a high level of confidence that can be expected to benefit essentially every activity touching on human nutrition research, education, and policy.

Better estimates of the mean nutrient content of foods will allow individuals to be more accurately classified according to nutrient intake. This will improve the ability to detect etiologic relationships; delineate biologic mechanisms; assess time trends in nutrient intake; and define populations at nutritional risk. Better estimates of the variance in nutrient content will allow foods to be more rationally classified and grouped, This will improve the development of dietary intake methods that depend on categorization of foods; the monitoring of the nutritional adequacy of the food supply; the design of dietary guidance for the healthy; and the planning of
therapeutic diets for the sick.

II. Specific Aims

Each Specific Aim (SA) plays a role in an integrated research program that takes advantage of the results of national food consumption surveys; recent advances in sampling statistics, data evaluation methodology, and analytical chemistry; and information on product alterations in the national food supply. The data yielded by each phase of the program will become an inherent part of the new USDA National Nutrient Databank System.

SA 1: Evaluation of existing data for scientific quality
Newly developed algorithms will be used to review essentially all of the existing data in the NNDB. This process will allow the data to be classified into three groups: a) data of fully satisfactory analytical quality; b) marginally satisfactory data needing upgrading; and c) unsatisfactory data needing replacement. This Specific Aim will identify areas with the highest need for improved data and data gaps where no prior information is available.

SA 2: Identify Key Foods and Critical Nutrients for sampling and analysis
National data on public health and research priorities and on food consumption and production patterns will be used to rank major contributors to nutrient intake. This information will combined with the results of Specific Aim 1 to identify those foods and nutrients most needing new sampling and analysis. The U.S. food supply is enormously

varied, but preliminary data indicate that 1000 foods will account for approximately 85% of the intake of most nutrients.

SA 3: Devise and implement a nationally-based sampling survey of U.S. foods
The NFNAP will have a probability-based design in order to reduce bias, minimize unpredictable accrual of data, and ensure that the data are truly representative of the national food supply. This will be achieved through a 5-stage sampling survey: a) identifying population units (foods) of interest; b) characterizing the foods for sources of variance and other stratifying factors; c) defining sample size for each stratum; d) locating and collecting the food samples; and e) preparing samples for analysis.

SA 4: Analyze sampled foods under USDA-supervised laboratory contracts.
Data on the composition of foods will be obtained through direct assay with up-to-date analytical methodology. Rigorous quality control programs based on use of standard reference materials and thorough documentation will maximize reliability and accuracy of analytical data. Edible yield and nutrient retention factors will be updated by analyzing foods prepared according to the methods most commonly used at present.

III. Budgetary considerations

A. Description

Accomplishing the NFNAP Specific Aims will require a substantial fiscal commitment. These commitments will be needed in several categories: l)funds that can be used for contracts and procurements; 2) USDA staff effort; and 3) in-kind support from other Federal agencies. Apart from the necessary USDA staff effort, total basic contract and procurement costs for the research plan are estimated to be approximately $15 million, distributed over 5 years. Costs will be relatively lower in Year 01 (FY 1997) while the statistical design, laboratory prequalification, and data evaluation phases take place, and higher thereafter in Years 02-05 (FY 1998-2001). Once the protocol has been developed, sampling and analysis of foods will be conducted in proportion to available funds. Costs in Years 02-05 would be proportional to the number of foods analyzed (approximately 250 foods/year). Resources above this level would permit yet more thorough sampling approaches and analysis of specialty components.

SA 1 and SA 2 will have costs for expert consultation, laboratory quality control programs, and standardization activities. SA 3 will have costs associated with statistical design activities and the collection and preparation of food samples. SA 4 costs for chemical analysis will use the majority of the contract funds, because the laboratory assays for generating new food composition data are expensive. Each Specific Aim also requires USDA staff effort and infrastructure support.

B. Status of Interagency Funding for the NFNAP

Full implementation of the NFNAP research plan requires the support of many cooperating parties. The program was initiated in FY97 with funds from the USDA, the National Heart, Lung and Blood Institute (NHLBI), the National Eye Institute (NEI), the National Institute of Child Health and Human Development (NICHD), the National Center for Health Statistics, the Health Resources and Services Administration, and the Indian Health Service. Authorizations for FY98 and later years have been received from USDA, NHLBI, NEI, NICHD, the National Cancer Institute (NCI), the National Institute for Deafness and Other Communication Disorders (NIDCD), and the National Institute of Dental Research (NIDR). As of this date, more funds are needed. Other Federal agencies with programmatic responsibilities in human nutrition have been asked to provide complementary co-funding so that the planned workscope may be carried out in full. Private sector parties also can help to support the NFNAP through in-kind participation as well as donations to the appropriate agency gift funds.

C. Program management

The NFNAP is an interagency program conducted under the aegis of the USDA Nutrient Data Laboratory. NHLBI is available to serve as the coordinating unit for Interagency Agreement contracts between participating agencies and the USDA. Project Officers for the NFNAP are:

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V. Schedule of Activities

An overview of the five-year plan for the NFNAP is shown below. It is anticipated that a Monitoring and Surveillance phase would be instituted after this intensive data collection phase is complete. The time line is based on information available as of September 1997. Modular budgeting and activity units will accommodate the likelihood that financial commitments would be phased in over the course of one or more fiscal years. Adherence to the schedule and completion of the workscope is contingent upon authorization of funds.

Dates	Activities and Related Specific Aims (SA)
FY1997 (Year 01)	Planning and setup. Protocol development initiated, including sampling and analysis plans. Specific Cooperative Agreements, Research Support Agreements, and contracts awarded for contract laboratories and collection contractors. Analytical laboratories prequalified Pilot studies for analytical laboratories initiated. Laboratory quality control (QC) program developed; QC oversight lab identified. Data evaluation phase initiated (SA 1). Key/Other Foods and Critical/Other Nutrients lists - development initiated (SA 2). Sampling plan - development initiated (variance sources) (SA 3).
FY1998 (Year 02)	Data evaluation phase (SA I) continues. Key/Other Foods and Critical/Other Nutrients lists: development completed (SA 2). Sampling plan - development completed (SA 3). Standard Reference Materials developed. Protocol completed and peer-reviewed by NIH-convened expert panel. Sampling and analysis of foods (SR 3, SA 4): Priority I: Critical Nutrients in Key Foods. Database updated.
FY 1999 (Year 03)	Data evaluation phase completed (SA 1). Sampling and analysis of foods (SA 3 and SA 4): Priority I: Critical Nutrients in Key Foods Priority 2a: Critical Nutrients in Other Foods Priority 2b: Other Nutrients in Key Foods Database updated.
FY 2000 (Year 04)	Sampling and analysis of foods (SA 3 and SA 4): Priority 1: Critical Nutrients in Key Foods Priority 2a: Critical Nutrients in Other Foods Priority 2b: Other Nutrients in Key Foods Priority 3: Other Nutrients in Other Foods Database updated.
FY 2001 (Year 05)	Sampling and analysis of foods (SA 3 and SA 4): Priority 2a: Critical Nutrients in Other Foods Priority 2b: Other Nutrients in Key Foods Priority 3: Other Nutrients in Other Foods Database updated.
(FY 2002-) (Year 06-)	Monitoring and surveillance phases begin.

DO AVAILABLE FOOD COMPOSITION DATA FOR FOLATE MEET CURRENT RESEARCH NEEDS?

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Abstract

Reliable food composition data for folate are needed: a) for use in estimating and evaluating the adequacy of folate intakes of populations, b) for formulation of experimental diets in folate nutrition studies, and c) as a component in the development of dietary recommendations (e.g. RDA and RDI values). Most of the current values for folate in databanks are derived from assay procedures that are now known to underestimate folate content. Improvement and optimization of several key components of the folate assay are needed. The ineffectiveness of common extraction techniques causes folate values to be erroneously low in many assays of food folate using traditional methods. Application of "trienzyme" procedures to folate extraction, in addition to selection of proper extraction conditions, improves the accuracy of folate measurements. Data will be presented indicating substantial underestimation of folate content in representative foods and diets when assayed by traditional methods as used in major databanks.

A review of estimates of folate intake (derived from food intake estimates and food composition databank values) indicates apparent intakes in the range of ~200-300 µg/d for many adults. Such estimates of folate intake have been shown to be correlated with measures of nutritional status in several studies, although it is highly likely that actual intake is underestimated. Precisely controlled nutritional studies have shown that an intake of 200 µg/d in highly bioavailable form is inadequate for nonpregnant women, while observational studies have concluded that an estimated dietary folate intake of ~200 µg/d maintains adequate folate nutriture in spite of a typical bioavailability of most food folate of only ~50%. Such conflicting data can only be explained by the fact that estimated intakes are erroneously low because of the inadequacy of current food composition data.

There is a great need for further refinement and optimization of methods for measurement of folate in foods. An optimized method should be applied with the objective of replacing existing databank values for the folate content of foods. Emphasis should be placed initially on classes of foods whose consumption level and concentration of naturally occurring folate make them significant dietary sources of this vitamin. Additional emphasis should be placed on providing accurate values for all foods containing added folic acid.

INTRODUCTION

Our understanding of the connections between folate nutritional status and public health is becoming firmly established, but there is a great need to define more closely the relationships between folate intake and many aspects of health. Among the metabolic functions of this vitamin are: a) participation in recycling of methionine and related formation and transfer of methyl groups, b) regulation of the concentration of plasma homocysteine, and c) involvement in nucleic acid synthesis through its role in the formation of purines and thymidylate. Through these roles, folate is essential for cellular development and homeostasis. Epidemiological studies have shown that inadequate folate status is associated with increased incidence of neural tube defects and certain other birth defects, elevated risk of various forms of vascular disease including coronary heart disease, and increased risk of several types of cancer. Since January 1, 1998, folic acid enrichment has been required in many types of cereal-grain based foods (FDA 1996). This enrichment is estimated to provide approximately 100 µg of additional folate daily per capita.

Data regarding the folate content of foods are used in many ways. Such data allow estimation of dietary intakes, from which dietary adequacy can be evaluated. Food composition data are also essential in the formulation of diets for experimentally controlling folate intake and in the development of dietary advice by health professionals. Finally, food composition data provide one criterion in formulating dietary recommendations (e.g. Recommended Dietary Allowances). For example, a folate intake that provides adequate nutritional status for a population may be viewed as meeting the nutritional needs of that population and, thus, provides indirect evidence of the requirement for available dietary folate (see reviews: Herbert 1987, NAS 1989). The reliability of all such applications of dietary folate data depends on the quality and accuracy of the analytical values in the database(s) used. The purpose of this discussion is to illustrate how existing food composition data do not fulfill the needs of the nutrition and public health communities, with primary focus on: a) inadequacies of analytical methods upon which most databanks are based; b) the probable inaccuracy of estimates of folate intake of the U.S. population; and c) the impact of inaccurate analytical data on many currently held views of folate requirements.

ANALYTICAL LIMITATIONS OF FOOD COMPOSITION DATA

Nearly all databank values regarding the folate content of foods have been gathered using microbiological assay procedures. Although many advances have been made in the determination of the individual forms of folates in foods by liquid chromatographic techniques (e.g. Pfeiffer et al. 1997b, Seyoum and Selhub 1993), microbiological assays probably will remain the method of choice for routine use in determining total folate. The key elements of this assay include extraction of folates from the sample matrix, enzymatic deconjugation of polyglutamyl folates, and quantification using the folate-dependent

bacterium *Lactobacillus casei* that responds nearly equally to all forms of the vitamin (Tamura 1990, 1998). The array of possible folates in foods is summarized in Figure 1. Major naturally occurring forms of the vitamin are polyglutamates of 5-methyl-tetrahydrofolate, and to a lesser extent 5- and 10-formyl-tetrahydrofolate, and unsubstituted tetrahydrofolate. Synthetic folic acid added to enriched or fortified foods also comprises a significant fraction of total folate intake. Assays must be able to provide a reliable measure of all forms present in a particular food sample. Although unresolved issues concerning the conditions of the microbiological growth assay still remain (e.g. optimal pH; Phillips and Wright 1983), many more problems can arise from inadequate extraction and/or enzymatic deconjugation (Engelhardt and Gregory 1990, Gregory et al. 1990, Pfeiffer et al. 1997b).

It is important to recognize that there is no current official method for measurement of total folate in foods. Since 1960, the Association of Official Analytical Chemists has listed a microbiological assay method for folic acid in vitamin preparations (AOAC 1990). This method is not suitable for food analysis because it employs *Streptococcus faecalis* (also called *Enterococcus hirae* and *Streptococcus faecium*, ATCC 8043) as the assay organism. This organism does not respond to 5-methyl-tetrahydrofolate, the most common naturally occurring form of the vitamin. A microbiological assay using *Lactobacillus casei* has been collaboratively validated and accepted as an AOAC official method for measurement of total folate in infant formula (AOAC 1995). The key aspects of sample preparation (i.e. extraction and deconjugation) needed for reliable application of this method to other foods have not been optimized.

The critical importance of proper sample extraction is illustrated by the following example (Gregory et al. 1990). Representative foods (frozen peas and calf liver) were subjected to microbiological assay for total folate using *L. casei* following thermal extraction using a pH 4.5 acetate buffer (with 50 mM ascorbate), a pH 7.0 phosphate (with 50 mM ascorbate), or a pH 7.85 HEPES-CHES buffer (with 101 mM ascorbate + 200 mM 2-mercaptoethanol). As shown in Table 1, choice of extraction buffer has a large impact on total measured folate in these and undoubtedly other types of foods. It should be noted that the most effective extraction method yields a value for total folate that exceeds the USDA Nutrient Database value by ~144% for frozen peas and 319% for calf liver. Most traditional folate analyses involve homogenization and heating of the sample in a buffer of ~pH 7 containing ascorbate. Even though the pH 7.85 buffer used in this study does not yield fully optimal results (as will be discussed later), these results strongly suggest that the traditional extraction procedures would cause the assay to underestimate substantially the actual folate content. It should also be noted that this phenomenon is observed when analyzing by HPLC; thus, the increase in folate yield is not simply an artifact of the microbiological assay.

The need for optimization of enzymatic deconjugation also exists. In this regard, the time of incubation and/or quantity of enzyme must be determined for each type of food sample

because of the presence of conjugase inhibitors in many foods (Engelhardt and Gregory 1990, Pfeiffer et al. 1997b). Insufficient enzymatic deconjugation yields underestimation of folate in either microbiological or HPLC assays (Engelhardt and Gregory 1990, Pfeiffer et al. 1997b). This effect probably contributes to the underestimation of food folate in databanks.

As discussed in this symposium by Dr. Jeanne Rader of the FDA, a great deal of evidence indicates that the use of protease and amylase treatments, in addition to deconjugation with folate conjugase, enhances the yield of measurable folate in many foods (e.g. DeSouza and Eitenmiller 1990, Martin et al. 1990, Pfeiffer et al. 1997b, Tamura et al. 1997, Tamura 1998). It is apparent to many analysts that this "trienzyme" approach is the method of choice for measurement of folate in foods. Dr. Rader will describe FDA activities in optimizing and testing a trienzyme procedure which, in conjunction with the *L. casei* microbiological assay, will probably become the official method for analysis of cereal-grain foods for regulatory purposes. It is possible that a systematic evaluation of extraction conditions (time, temperature, sample/extractant ratio, etc.) might eventually eliminate the need for the lengthy enzymatic treatment. However, the trienzyme procedure provides a great advance over traditional approaches to folate analysis, and its use should be continued to improve our understanding of the actual content and dietary intake of folate. An example of data for total dietary folate analysis of eight different diet composites is provided in Table 2 which illustrates the value of trienzyme analysis. It is clear from these data that conventional assays not employing the trienzyme approach would underestimate total folate content or intake regardless of the extraction buffer employed.

One caveat is needed regarding trienzyme methods of folate assays at this time: only in the case of cereal-grain foods has it been established that the response to amylase and protease treatment is due solely to enhanced extraction of folate (Pfeiffer et al. 1997). The potential for enzymatic generation of growth factors for *L. casei* cannot be totally ruled out at this time when trienzyme-based extraction methods are applied to other types of foods. Recent studies regarding the analysis of cereal-grain products have shown that the results of properly calibrated HPLC and microbiological assays are equivalent for samples conventionally extracted and prepared (i.e. conjugase alone) and those prepared with a trienzyme treatment (Pfeiffer et al. 1997). These findings support the validity of trienzyme-based folate analysis, similar to that used in the FDA method, for measurement of folate in cereal-grain foods. Although it is anticipated by this author that trienzyme-based folate analysis will be shown to be accurate for other types of foods (e.g. Table 2), comparisons with validated HPLC results are needed to confirm the specificity of the trienzyme-based *L. casei* assay prior to its widespread application.

The details of folate assays used to generate the major nutrient databanks often have not been reported. In view of the many apparent limitations of traditional analytical methods used in generating the food composition data for folate, it appears highly likely that current databank values, the majority of which were generated prior to current applications of

trienzyme methods, underestimate actual folate content. It is likely most of the USDA databank values were generated using an extraction method employing a buffer such as 0.1 M phosphate buffer, pH 7.0, with 1% ascorbate followed by conjugase treatment (personal communication from J. Holden, Nutrient Data Laboratory, USDA/ARS). This is analogous to the phosphate buffer extraction that yielded a large underestimation of folate content in analysis of peas and liver shown in Table 1. As shown in Table 2 regarding the measurement of total folate in diet composites, trienzyme treatment provides further enhancement of extraction above that obtained with the pH 7.85 buffer and conjugase alone. As shown in Table 3, the use of the trienzyme method in analysis of these food composites has a great effect on estimated daily folate intake calculated from this analysis. Unfortunately, the difference between results of folate assays conducted with or without trienzyme methods between probably varies from food to food (Table 2). Trienzyme treatment gave a 35.4% mean increase, but the range was 10.1% to 94.2%. Thus, there is no way to predict actual folate content from the databank values by applying a "correction factor." There is a growing consensus (Pfeiffer et al. 1997b, Tamura et al. 1997, Tamura 1998) that trienzyme-based analysis should be used to generate reliable food composition data. However, as mentioned above, there is a need for further confirmation of the specificity of this assay prior to its general acceptance.

LIMITATIONS OF FOOD COMPOSITION DATA FOR ESTIMATING FOLATE INTAKE IN NUTRITION RESEARCH STUDIES

Many researchers have estimated the folate intake of various experimental groups and subsets of the population by using food composition databanks and measures of food intake (e.g. food records, food frequency techniques, etc.). A representative but not exhaustive survey of such estimates is shown in Table 4.

Mean estimated intake of dietary folate in women ranged from ~200-300 µg/d, while that of men ranged from ~280-325 µg/d. Most of these estimates were based largely or entirely on data from the USDA Nutrient Database. Variation in estimated folate intake among these studies could reflect differences in assessing food consumption, number of subjects evaluated, and real differences in food selection patterns (e.g. intake of fortified breakfast cereals). However, the accuracy of all estimates rests primarily on the accuracy of the values in the databank(s) used. For analytical reasons discussed previously, it is highly likely that all of the estimates of dietary folate intake underestimate actual intake. Aside from the analytical issues, it is also likely that the apparent lower intakes in some studies may be related in part to incomplete food tables, especially in early studies. Also, published values do not take into account seasonal variation in nutrient content or cooking/preparation methods that differed from those used in samples analyzed to generate databank values.

In spite of the underestimation of folate intake, another aspect of whether food composition data meet research needs is whether estimated intakes are associated with actual folate

nutritional status. Jacques et al. (1993) reported initial evidence that estimates of folate intake derived from food frequency analysis were significantly correlated with folate nutritional status. In a more recent study that evaluated incidence of coronary heart disease in over 80,000 nurses, relative risk of coronary heart disease was inversely related to estimated total folate intake from food or supplements (Rimm et al. 1998). These authors also stated that "The relative risk for a diet high in folate was virtually identical after excluding the 33.7% of women who reported use of vitamin supplements." Thus, the food composition data used (derived largely from the USDA Nutrient Database) was sufficiently reliable to allow classification of subjects by quintile of folate intake, which indicated that intake was inversely related to relative risk of coronary heart disease. Similar associations have been observed in the elderly population of the Framingham study (Selhub et al. 1993, Tucker et al. 1996b). In these studies, estimated folate intake (diet + supplements) was classified by decile and shown to be proportional to plasma folate concentration and inversely related to plasma homocysteine concentration. Thus, available food composition data are at least suitable for classifying intakes, such as by quintiles (Rimm et al. 1998) or deciles (Selhub et al. 1993, Tucker et al. 1996b). It is interesting to note that the intake of folate-rich foods is also predictive of folate nutritional status. In this regard, Tucker et al. (1996a) observed strong relationships between measures of folate status (plasma homocysteine and folate concentrations) and weekly frequency of intake for breakfast cereals as well as fruits and vegetables.

HOW ACCURATE ARE OUR CURRENT ESTIMATES OF FOLATE INTAKE?

The exact nutritional requirement for folate is unclear, although clear experimental evidence indicates that the 1989 Recommended Dietary Allowance (RDA) values are insufficient. The author and colleagues (O'Keefe et al. 1995) conducted a study in which young women were fed for 10 wk a low-folate diet (30 µg/d folate from food sources). The women were supplemented with synthetic folic acid dissolved in apple juice to provide total folate intakes of either 200, 300, or 400 µg/d. Under the conditions of this protocol, with careful dietary control and an accurate knowledge of intake, the 200 µg/d intake did not provide sufficient folate as reflected by changes in plasma and red cell folate and plasma homocysteine concentration. This is strong evidence that the requirement is higher than previously believed.

A "Recommended Dietary Intake" of 3 µg folate/kg body weight was reported by Herbert (1987), which was based in part on observations from several studies of apparent nutritional adequacy of populations with dietary folate intakes in the range of ~200 µg/d. This approach also was used in developing the 1989 RDA values (180 µg/d for women, 200 µg/d for men; NAS 1989).

How can one reconcile these observations? On one hand are studies and recommendations indicating that ~200 µg/d of folate from dietary sources (having incomplete folate bioavailability) would be adequate, while on the other hand is a

controlled study which showed that 200 µg/d primarily from highly absorbable folic acid did not meet nutritional needs (O'Keefe et al. 1995). Differences in these views of folate requirements are amplified when one considers the bioavailability of the folate consumed. The bioavailability of naturally occurring dietary folate is incomplete, perhaps 50% on the average (Cuskelly et al. 1996, Sauberlich et al. 1987, Gregory 1995), while the bioavailability of folic acid consumed with food is considerably higher (Pfeiffer et al. 1997a). The answer to this dilemma is that the studies employing current food composition databanks substantially underestimate actual intake. Thus, conclusions regarding dietary allowances should not be based solely on estimated folate intake from current food composition databanks.

The Food and Nutrition Board, Institute of Medicine has released new dietary recommendations (IOM 1998). They defined an Estimated Average Requirement (EAR) for adults (men and women 19-50 yr) of 320 µg dietary folate equivalents per day and a Recommended Dietary Allowance (RDA) of 400 µg dietary folate equivalents per day (IOM 1998). These contrasted markedly with the 1989 RDA values for folate of 180 and 200 µg per day for women and men (NAS 1989), respectively. The rationale behind this increase was recent metabolic data indicating higher requirements and, as described in this paper, the mounting evidence that actual folate intakes are greater than previously believed.

SUMMARY and RECOMMENDATIONS

There are two take-home lessons from this discussion regarding the significant limitations of existing food composition data for folate. First, there is a great need for refinement of methods for measurement of folate in foods. Although recent advances have been made, standardization and optimization are still needed. Second, an optimized and validated method should be applied to foods with the objective of replacing existing databank values for the folate content of foods. Emphasis should be placed initially on classes of foods whose consumption level and concentration of naturally occurring folate make them significant dietary sources of this vitamin. Additional emphasis should be placed on accurate values for all foods containing added folic acid. Differences in bioavailability have been shown to exist between naturally occurring folate and added folic acid. For this reason, data for enriched/fortified foods would be most useful if separate listings were provided for total folate and added folic acid, as recommended recently (IOM 1998).

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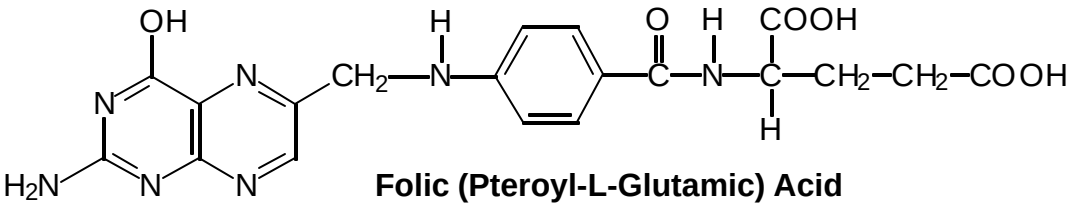
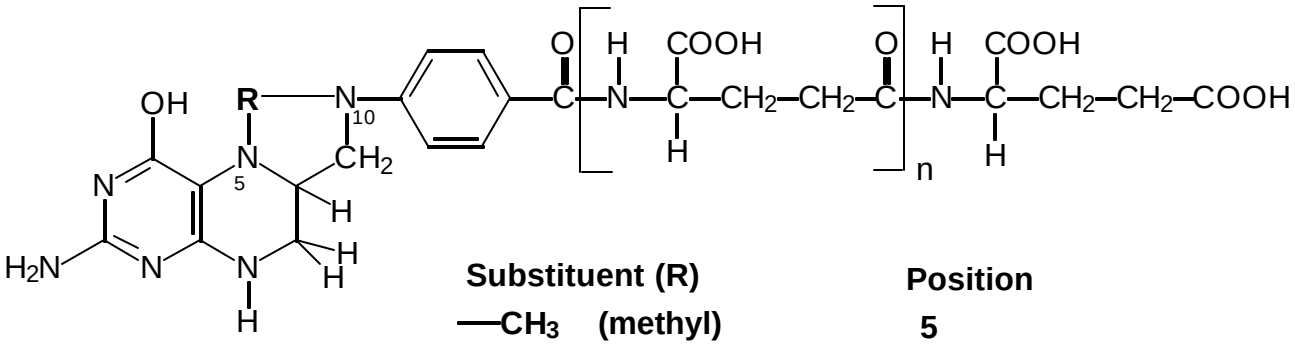
Figure 1. Structures of common folates.



Folic (Pteroyl-L-Glutamic) Acid

Polyglutamyl Tetrahydrofolates



Substituent (R)		Position
—CH_3	(methyl)	5
—CHO	(formyl)	5 or 10
—CH=NH	(formimino)	5
—CH_2—	(methylene)	5 and 10
—CH=	(methenyl)	5 and 10

Table 1. Effect of extraction buffer pH and composition on total measured folate (Gregory et al. 1990). Current values from USDA Nutrient Database (USDA 1997) are provided for comparison.

Food Sample	Extraction Buffer			USDA Nutrient Database value[#]
	pH 4.9 acetate buffer (+ ascorbate)	pH 7.0 phosphate (+ ascorbate)	pH 7.85 HEPES-CHES buffer (+ ascorbate & mercaptoethanol)	
Frozen peas, not prepared (µg/g)	0.494 ± 0.044	0.538 ± 0.009	0.979 ± 0.053*	0.402
Raw calf liver (µg/g)	11.3 ± 5.6	13.0 ± 0.44	26.9 ± 1.3*	6.42

*Significantly greater than other extraction methods, $P<0.05$.
[#]Data from USDA Nutrient Database for Standard Reference, Release 11-1 (1997).

Table 2. Analysis of eight different diet composites for total folate by *Lactobacillus casei* assay with conjugase treatment alone or with trienzyme treatment to enhance extraction.

	Total Folate Concentration (µg/100g homogenate)		
Experimental Diet	**Conjugase alone**	**Trienzyme**	**Increase (%)**
a	4.20	5.99	42.6
b	5.84	7.29	24.8
c	4.57	5.81	27.1
d	6.27	7.42	18.3
e	5.72	7.05	23.3
f	7.07	10.1	42.9
g	19.8	21.8	10.1
h	7.62	14.8	94.2
Mean±SD			35.4 ± 26.3

Values are means of duplicate analyses (A. D. Mackey and J. F. Gregory, unpublished) by method of Pfeiffer et al. 1997. Samples extracted using pH 7.85 HEPES-CHES buffer (ascorbate + mercaptoethanol). Samples obtained from composites of eight different diets from a controlled folate nutrition study conducted by Drs. P. B. Duell and M. R. Malinow, unpublished.

Table 3. Estimated folate intakes derived from analysis of diet homogenates for total folate by *Lactobacillus casei* assay with conjugase treatment alone or with trienzyme treatment to enhance extraction.

	Total Dietary Folate Intake (µg per day)		
Experimental Diet	**Conjugase alone**	**Trienzyme**	**Increase (%)**
a	95	135	42.6
b	140	175	24.8
c	97	123	27.1
d	147	175	18.3
e	192	236	23.3
f	221	317	42.9
g	577	634	10.1
h	220	427	94.2
Mean±SD			35.4 ± 26.3

Values are means of duplicate analyses (A. D. Mackey and J. F. Gregory, unpublished) by method of Pfeiffer et al. 1997. Samples extracted using pH 7.85 HEPES-CHES buffer (ascorbate + mercaptoethanol). Samples obtained from composites of eight different diets from a controlled folate nutrition study conducted by Drs. P. B. Duell and M. R. Malinow, unpublished.

Table 4. Summary of representative estimates of folate intake from dietary sources. All values shown are for intakes prior to inclusion of folic acid in cereal-grain enrichment in ~1997.

Investigators or Study	Estimated Folate Intake ± SEM* (µg/d)
CSFII, 1985-86; women, 20-49 yr (LSRO 1989)	193 ± 3.1 (n=2056)
NHANES II / Subar et al. (1980)	
women, 19-74 yr	207 ± 2.9 (n=5835)
men, 19-74 yr	281 ± 3.6 (n=5331)
Brown et al. (1997)	
women, 22-35 yr	255 ± 9 (n=189)
Tucker et al. (1996a)	
men and women, 67-95 yr	276 (n=667)
Rimm et al. (1998); women, 30-55 yr, (values	366 (mean, n=80082)
include supplements at 26% of intake)	277 (median)
CSFII (1989-91), Guenther et al. (1997)	
women, not pregnant or lactating, ≥ 20 yr	221 (n=4621)
men, ≥ 20 yr	292 (n=3381)
CSFII (1994-96), cited by Koehler et al. (1997)	
women, ≥ 20 yr	226 (n=4816)
men, ≥ 20 yr	301 (n=5056)
Koehler et al. (1997)	
men and women, 65-94 yr	300 ± 6 (n=308)
NHANES III (Dodd & Carriquiry, 1997)	
women, 19-30 yr	254 ± 3.6 (n=1972)
women, 31-50 yr	255 ± 3.0 (n=2988)
women, 51-70 yr	269 ± 3.6 (n=2076)
women, ≥ 71 yr	275 ± 4.2 (n=1368)
men, 19-30 yr	313 ± 5.1 (n=1942)
men, 31-50 yr	317 ± 4.1 (n=2533)
men, 51-70 yr	322 ± 4.9 (n=1942)
men, 71≥ yr	302 ± 5.4 (n=1255)

*RDA values (1989): 180 µg/d for women ≥ 19 yr, 200 µg/d for men ≥ 19 yr. Values shown are means±SEM, with supplement use excluded, unless otherwise indicated. CSFII, USDA Continuing Study of Food Intakes of Individuals; NHANES, National Health and Nutrition Examination Survey.

FOLIC ACID: CONSIDERATIONS REGARDING FOOD VALUES IN DATABASES.

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The need for current and validated databases for nutrients in foods is very apparent as dietary guidance increasingly focuses on specific nutrients or classes of nutrients and their roles in reducing risk of chronic illness. Folate is a critically important micronutrient because increased intakes of this B vitamin by some women may reduce their risk of a neural tube birth defect-affected pregnancy (DHHS/PHS, 1992).

On March 5, 1996, FDA finalized regulations mandating the fortification of a wide range of enriched cereal-grain products with folic acid. FDA took this action to assist women of childbearing age in meeting the Public Health Service recommendation that they consume 400 ：g folate per day to reduce their risk of having a pregnancy affected with a neural tube birth defect (FDA, 1996a, 1996b, 1996c).

USDA database values for folate in foods played an important role as FDA developed its fortification proposals (FDA, 1993a, 1993b). FDA used Nationwide Food Consumption Survey (NFCS) data along with the folate composition data base that provided specific information on folate content of foods and food ingredients to estimate "usual" daily folate intakes from all sources. The agency then estimated the potential impact of various fortification options by altering the folate composition of selected foods and ingredients in the data bases and recalculating intakes. For example, the agency recalculated intake estimates to determine potential intake levels if, for example, all cereal-grain products were fortified with 70 ：g folic acid/100 g or with 140 ：g folic acid/100 g, etc. (Crane et al., 1995). The availability of ingredient data allowed FDA to estimate potential effects on folate intakes that could result from fortifying the flour consumed in breads, rolls, buns or cake as well as the flour consumed as a component of, for example, a frozen dinner (e.g., in pizza crust, noodles, breadings, etc.)

The validity of these estimates is dependent upon the accuracy of the folate data in the data bases. Two potential sources of underestimation in the calculation of intakes were noted in FDA's fortification documents: (1) There is general agreement that methods currently used for folate analysis are unsatisfactory and very likely underestimate the folate content of foods. Comparisons of newer methods of sample preparation with older methods have consistently revealed underestimates in the range of 20 to 50 percent for some products; and (2) Manufacturers frequently add overages of nutrients such as folic acid to products to ensure that the product contains at least the amount of the nutrient shown on the label. Because, in updating food composition data bases, label values were used to define the folate composition of some fortified foods (e.g., ready-to-eat cereals, dietary supplements), the values that the agency used are likely to understate the actual folate content of such foods.

January 1, 1998 was the full compliance date for the new fortification regulations (Table

1) (FDA, 1996b). This deadline again focused attention on the need for validated methods for folate analysis. Difficulties with traditional methods of analysis include incomplete release of folates from food matrices and incomplete hydrolysis of folylpolyglutamates prior to quantification (Gregory et al., 1989; Tamura, 1990; IOM, 1998).

There is currently no official method for the analysis of folate in foods. Association of Official Analytical Chemists (AOAC) official method 992.05 (Folic Acid Pteroyl-monoglutamic Acid in Infant Formula) which uses Lactobacillus casei (L. rhamnosus) (AOAC, 1995), is a microbiological method that was developed for analysis of folate in infant formula. This method proved to be a suitable starting point from which to develop a method for use with cereal-grain products. While AOAC official method 992.05 was not intended for measurement of total folate, the method can measure folate indigenous to infant formula ingredients other than added folic acid because it includes the deconjugation step with chicken pancreas conjugase (Eitenmiller and Landen, 1995). Additional extraction steps that are needed include the use of "-amylase and protease. Use of extractions employing these enzymes has been shown to increase the yield of folates from high starch or glycogen-rich foods and from high protein foods ("-amylase, and protease, respectively)(DeSouza and Eitenmiller, 1990).

We undertook studies to determine the pre-fortification levels of folate in enriched cereal-grain products that would be subject to the new regulations. We also needed to identify and validate modifications of AOAC official method 992.05 that were expected to lead to a method suitable for a collaborative study for the determination of folates in cereal-grain products. The process of validating the microbiological assay for cereal-grain products included determining optimal conditions for use of the enzymes, optimal pH, the response of the assay microorganism Lactobacillus casei to calibrants other than folic acid, recoveries of calibrants added to food samples, analysis of a folate-containing Standard Reference Material, and analysis of folate-containing samples from the check sample program of the American Association of Cereal Chemists. Representative cereal-grain products were then analyzed by the single enzyme (i.e., conjugase only) procedure and by the tri-enzyme assay to gain insight into the extent to which the former methodologies may have underestimated the folate content of cereal-grain products.

Analyses of breads, flours, corn grits and meals, rice, macaroni and noodle products were included in our studies. Fifty-seven such products were analyzed by the single enzyme assay and 37 of the products were assayed by the new tri-enzyme methodology. With respect to necessary validation steps, we found that treatment of digests with 20 mg of the chicken pancreas preparation for 4 hours was sufficient for the cereal-grain products we studied. Other aspects of the validation procedure, including recovery studies of folate added to cereal-grain foods, use of other calibrants, analysis of folate in an infant formula Standard Reference Material and analysis of folate in check samples from the American Association of Cereal Chemists, are described by Rader et al. (1998). It is important to recognize that the conditions we

identified for cereal-grain products may not be adequate for all types of foods. As Dr. Gregory emphasized earlier in this symposium, optimal conditions must be carefully identified for specific food types. While we optimized conditions of extraction for cereal-grain products, we do not know whether these conditions will be adequate for all types of foods. In this area alone, considerable work remains to be accomplished.

Levels of folate in 24 enriched bakery products, wheat flour, corn grits, corn meals, rice, macaroni and noodle products are listed in Tables 2 and 3. All of these products were analyzed by both the single-enzyme and tri-enzyme procedures. Of the 11 products listed in Table 2, 8 showed significantly increased levels of folate when assayed by the tri-enzyme procedure. Four (4) of 13 products listed in Table 3 showed significantly increased levels of folate when assayed by the tri-enzyme procedure. Two (2) of the enriched macaroni products (i.e., trio shells, large shells) were found to be fortified with folic acid at levels consistent with the March 5, 1996 regulations. The remainder of the products were not fortified at the time of product collection and analysis.

We also measured levels of folate in a wide range of ready-to-eat breakfast cereals and other breakfast foods. A sample of the results is shown in Table 4. The majority of these products identified an enriched cereal-grain component (e.g., enriched flour, enriched rice) in their ingredient lists. Many of these foods were fortified with folic acid. Results obtained by the single enzyme and tri-enzyme assays were not significantly different for these products.

At the time of sample collection for our studies, some cereal-grain foods were fortified with 10 to 100% of the Daily Value for folic acid (i.e., 40 to 400 ：g folate/serving). We compared label declarations for folate with the values found on analysis for the products listed in Table 5. Of particular interest was the finding that a wide variety of breakfast substitutes, broadly including foods such as frozen waffles, frozen pancakes, toaster pastries, granola bars, powdered instant breakfast beverages, breakfast bars, cereal bars, health bars, etc. were fortified with folic acid at levels up to 25 to 35% of the DV in some cases. These products make up about 20% of the total market for breakfast foods. In addition, products such as cereal bars, health bars, and granola bars are also eaten as snack foods. Consumption of such foods may contribute significantly to total daily folate intake. We found that the analyzed values for folate were 100 to 189% of the label declarations for a sampling of such products. The high values found may represent manufacturer's excess addition of folic acid in addition to endogenous folate in the products. The microbiological assay does not distinguish between "added" folate and "endogenous" folate in a food. As noted above, "overages" of nutrients are typically added to fortified foods. Because the microbiological assay measures "total folate" from all sources, it is not possible to quantify the "endogenous" component of folate in a fortified cereal-grain product and the "fortified" component in the product separately.

The essentiality of a tri-enzyme digestion has been clearly demonstrated by the work of

Pfeiffer et al. (1997) and Tamura et al. (1997). The work described here with a wide range of cereal-grain products has confirmed the need for tri-enzyme treatment during preparation of cereal-grain products for analysis of folate. All of these studies are in agreement that traditional extraction and conjugase treatments are not appropriate for the analysis of total folates from cereal-grain products.

The results obtained with the tri-enzyme procedure were significantly higher than results obtained with conjugase treatment alone for more than 30% of the cereal-grain products we examined. The results in Tables 2 and 3 indicate that the extent of differences between results obtained by the single enzyme and tri-enzyme methods varied from product to product. There is currently no way to predict with certainty how a specific product will respond to different extraction procedures. However, it is clear that failure to use a tri-enzyme extraction will lead to significant underestimations of folate content for many products.

With implementation of the new regulations, food composition tables will no longer be accurate for folate content of enriched cereal-grain products. While one might assume that it is possible to estimate with a high degree of confidence the folate content of an enriched cereal-grain product based upon the levels of folic acid required by the regulations, this is much more difficult in practice. This is because a manufacturer may add overages of folic acid of unknown magnitude to assure that the folate content of the food does not fall below the label declaration and because the food may also contain an unknown amount of endogenous folate to which the fortificant is added. In comparing "old" and "new" folate data, therefore, it is important to recognize that differences will derive from improved methods of analysis as well as from real changes in composition due to fortification. Thus, it is not possible to estimate current or "new" food folate values from "old" food folate data with a high degree of confidence.

To resolve these and other uncertainties, more attention needs to be focused on careful analysis of an increasing number and types of foods. It is likely that at least for the immediate future, new data on folate in cereal-grain foods will be more complete than new data for folate in other food categories. Additional attention must be directed toward validating methods for folate in those food categories with little or inadequate data (e.g., fruits, dairy products, vegetables, meat and poultry). It is also important to clearly identify fortified and unfortified foods in new data bases, and to recognize new classes of previously unfortified foods.

Issues regarding the folate fortification program will continue to draw wide attention. Issues that require further discussion and data gathering include: (1) needs to collaboratively test improved methods for folate analysis in enriched cereal-grain products; (2) needs to develop and collaboratively test methods for analysis of naturally-occurring folates in food groups for which current data are limited or unsatisfactory; (3) questions of how to use current food folate data in the context of an evolving data base; and (4) questions of how to update data bases so that they accurately reflect the total folate content of newly-fortified enriched cereal-grain

products as well as other important food sources of folate. A meaningful evaluation of the effectiveness of the folate fortification program cannot be made until current and much more accurate data on the total folate content of foods are available in the next generation of food composition databases.

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Table 1. Examples of fortification requirements for addition of folic acid to enriched cereal-grain products in the U.S.

STANDARDIZED PRODUCT	Folic acid mg/lb	Folic acid µg/100 g
§136 - BAKERY PRODUCTS		
Enriched bread, rolls, buns	0.43	95
§137 - CEREAL FLOURS & RELATED PRODUCTS		
Enriched flour	0.7	154
Enriched self-rising flour	0.7	154
Enriched corn grits	0.7-1.0	154-220
Enriched corn meals	0.7-1.0	154-220
Enriched farina	0.7-0.87	154-192
Enriched rice	0.7-1.4	154-308
§139 - MACARONI & NOODLE PRODUCTS		
Enriched macaroni	0.90-1.2	198-264
Enriched non-fat milk macaroni	0.90-1.2	198-264
Enriched noodle products	0.90-1.2	198-264

Table 2. Current levels of folate in enriched cereal-grain products measured after conjugase (mono-) and tri-enzyme digestions.

Product	Folate, μg/100 g			
	Mono-	Tri-	%	P
Enriched bread, rolls & buns				
White pita bread	23.8	30.3	127	<0.005
Whole wheat bread	62.9	60.7	97	NS
Enriched flour				
Wheat flour	26.1	33.1	127	<0.05
Wheat flour	24.8	32.2	130	<0.05
Baking mix	19.8	24.8	125	<0.05
Hot roll mix	33.5	38.6	115	NS
Enriched corn grits				
Instant grits	25.2	28.7	115	<0.05
Quick grits	27.5	31.5	115	NS
Enriched corn meals				
Yellow corn meal	32.6	37.5	115	<0.05
Yellow corn meal	25.3	29.2	115	<0.05
White corn meal	19.7	26.1	133	<0.05

Values are means of 2-3 independent determinations per product. Percent differences in results obtained by the single enzyme (mono-) and tri-enzyme (tri-) digestion procedures were calculated as follows: % =((Tri/Mono) x 100). P by t-tests. NS, not significant.

Table 3. Current levels of folate in enriched cereal-grain products measured after conjugase (mono-) and tri-enzyme digestions.

Product	Folate, ∶g/100 g			
	Mono-	Tri-	%	P
Enriched rice				
Medium grain rice	20.1	25.6	127	<0.1
Long grain inst rice	28.0	28.3	101	NS
Long grain wild rice	50.7	59.4	117	NS
Whole grain brown rice	23.7	31.3	132	<0.05
Enriched macaroni products				
Pasta	27.6	32.5	113	NS
Shells	31.4	39.6	126	<0.05
Thin spaghetti	35.1	39.0	111	NS
Thin spaghetti	35.6	37.8	106	NS
Trio shells	181.5	211.7	117	NS
Large shells	179.9	203.5	113	NS
Enriched noodle products				
Egg noodles	42.9	45.2	105	NS
Egg noodles w/o yolk	28.3	32.9	113	<0.1
Noodles & sauce	83.2	80.4	97	NS

Values are means of 2-3 independent determinations per product. Percent differences in results obtained by the single enzyme (mono-) and tri-enzyme (tri-) digestion procedures were calculated as follows: % =((Tri/Mono) x 100). P by t-tests. NS, not significant.

Table 4. Folate in ready-to-eat cereals measured after conjugase (mono-) and tri-enzyme digestions.

Product	Folate, μg/100 g			
	Mono-	Tri-	%	P
Breakfast cereals				
Whole wheat cereal	44.2	47.3	107	NS
Toasted rice cereal	397.6	450.1	113	NS
Whole grain oat cereal	416.6	419.5	101	NS
Bran cereal	629.3	677.8	108	NS
Other breakfast foods				
Whole grain wheat waffles	67.8	72.2	106	NS
Waffles	158.1	143.9	91	NS
Cereal bar,blueberry	278.7	295.2	105	NS

Values are means of 3-4 independent determinations per product. Percent differences in results obtained by the single enzyme (mono-) and tri-enzyme (tri-) digestion procedures were calculated as follows: % = ((Tri/Mono) x 100). P by t-tests. NS, not significant. The whole wheat cereal product was unfortified. Other products were fortified with folic acid at 40 to 400 μg/serving.

Table 5. Consistency between label values and analyzed values for folic acid-fortified foods.

Product	Folate			
	%DV /srv	µg/srv	Analyzed µg/srv	% of label value
Rice cereal snack	10	40	40	100
Toaster tart	10	40	58	145
Whole grain waffles	10	40	53	133
Waffles	20	80	107	120
Fruit-flavored drink mix	20	80	96	120
Toasted rice cereal	25	100	119	119
Whole grain oat cereal	25	100	125	125
Wheat & corn bran cereal	25	100	189	189
Multigrain cereal bar	25	100	115	115
Toasted corn,oats,wheat & rice cereal	100	400	398	100

Information on folic acid content obtained from product labels was compared with results obtained by analysis of the products. Values for folate on food labels are declared as the percent of the Daily Value (DV) that is present in one serving of the food. The DV for folate is 400 µg. Srv size, serving size. % of label value was calculated as follows = ((Analyzed/declared) x 100).

UPDATING FOLATE VALUES: USDA NUTRIENT DATABASE FOR STANDARD REFERENCE, RELEASE 12

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On March 5, 1996 the Food and Drug Administration published in the Federal Register the final rule amending the standards of identity for enriched grain products to require the addition of folic acid (FDA 1996a). The effective date for the regulation was January 1, 1998. This meant that a USDA Nutrient Database for Standard Reference containing updated values for folate in enriched grain products would need to be released in early 1998. The enriched foods that are listed in the regulation are flour; cornmeal and grits; farina; rice; macaroni and noodle products; and bread, rolls, and buns (Table 1). Flour and bread, rolls, and buns have specific levels of folate required. For cornmeal, farina, rice and macaroni and noodles, the required levels are given as a range as is true for the other B vitamins in these products.

The food additive regulations were also amended to provide for the addition of folic acid to breakfast cereals on a per serving basis and to permit its use in infant formulas, medical foods, and foods for special dietary use (FDA 1996b). FDA intended to restrict to breakfast cereals (foods for which standards of identity do not exist) to which folic acid may be added. Most breakfast cereals are currently fortified at 100 mcg folic acid per serving. There are a small percentage that are fortified at 400 mcg folic acid per serving. Because health claims can be made for the cereals fortified at 100 mcg per serving, there is no need for breakfast manufacturers to increase their level of folic acid fortification to qualify to bear the claim. FDA did say that it intends to monitor the marketplace, and should the proportion of breakfast cereals fortified at 400 mcg folic acid change substantially, it may find it necessary to reconsider its decision.

FDA considered the addition of folic acid to fruit juices and dairy products as well as cereal grain products. But, even at the lowest level of fortification they considered, 70 micrograms per 100 grams, intakes of high consumers exceeded the safe upper limit of 1 mg folate per day for most age groups. Because cereal-grain products are more widely consumed than dairy products or fruit juice by women of child bearing age, FDA only considered the addition of folic acid to cereal grain products and rejected comments recommending that fruit juice replacements be permitted to add folic acid.

The regulation also permits the continued addition of folic acid to infant formulas, medical foods, and foods for special dietary use. Meal replacement products that are intended to be consumed once per day may contain up to 400 mcg folic acid per serving. However meal replacements products intended to be consumed more than once per day may contain up to 200 mcg folic acid per serving.

The few foods mentioned in the regulation are just the tip of the iceberg for changes required for a nutrient database. Those foods are basic ingredients in many other

foods. Therefore, any food that contains one of these enriched grain products as an ingredient must be revised. In the Nutrient Data Laboratory, food specialists are responsible for the nutrient data and accompanying information for one or more food groups. Of the twenty-two food groups in the USDA Nutrient Data Base Standard Reference, fourteen were impacted by the change in folate levels. Some food groups had only one or two foods that required folate changes, others namely baked products, had several hundred food items where folate values had to be updated.

The food group most directly affected by the change in regulation is Cereal Grains and Pasta. It contains most of the basic foods that are covered by the regulation. A decision had to be made on what folate values to use for these items, since they would impact on items in other food groups. In September, 1997 the large flour producers, pasta, cornmeal, and rice companies and several enrichment premix suppliers were contacted. Many companies did not have analytical data for the folate content of their products; several cited problems with the analytical methodology; several were calculating the value based on the amount of folic acid in the vitamin premix they were using; others were going to claim the minimum level; one company sent data but the analytical method was not adequately described. We received analytical data on a couple pasta samples and flour from FDA. Of the analytical data we had the values ranged from 10% under the minimum level to more than 30% over the minimum. The opinion of the people contacted was that the analytical values we had represented the initial data from fortified samples and companies might be changing the levels as they had more experience adding the folic acid to their product. Also the few values that were available were not representative of the entire market.. The prudent decision was to use the specified enrichment level for flour and bread, rolls, and buns, and to use the mid-point of the range for cornmeal, farina, rice and pasta (Table 2).

In the database, the type of data for each nutrient value is identified by a source code. A “1" is analytical data, a “4" is an imputed value, a “7" is an assumed zero, a “9" is a value calculated by the manufacturer, and a “12" is manufacturer’s analytical data--it is used when there isn’t sufficient information supplied to evaluate the data and give it a source code of “1". We were only able to obtain manufacturer’s analytical or calculated data for a handful of foods. There were no analytical, source code “1", data available for the enriched grain products. It was necessary to impute the revised folate values for the vast majority of foods based on their content of the basic enriched grain products.

For Baked Products over 300 folate values were imputed. Recipes were used to calculate home prepared items. For commercial products, a linear regression program that uses the list of ingredients and known values for some nutrients to estimate the formulation was used (Marcoe and Haytowitz 1992). An example is biscuits. The formulation contained 9 ingredients. The program estimated the percentage of each ingredient. Only 3 of the ingredients, the enriched flour, dried buttermilk, and nonfat

dried milk contributed folate (Table 3).

To estimate the folate contribution of flour, the percent of flour in the biscuit is multiplied by the micrograms of folate in 100 grams of flour and a percent retention. The amount of folic acid contributed from the dried buttermilk and nonfat milk are also calculated and summed for a folate value of 59 micrograms for biscuits (Table 4).

Breakfast Cereals is another food group that is grain based. However, folic acid has been added to these foods for a long time and there was no incentive to increase the amount of folic acid per serving added to breakfast cereals. The only changes required in this food group were enriched corn grits and farina which were required by the regulation to have folic acid added.

In the Snacks and Sweets food group, enriched pretzels and corn based extruded puffs and chips needed revised folate values. The industry supplied manufacturer's analytical data for these items.

Fast Foods was a food group that required many changes because of the different types of sandwiches. There were breakfast sandwiches on biscuits, English muffins, croissants as well as hamburgers, hot dogs, cheeseburgers, and submarines on rolls and buns. There was also fried chicken and fish and pizza. Dessert items, including ice cream cones, had to be updated.

Meals, Entrees, and Side dishes is the newest food group added to Standard Reference. There were a few pasta dinners that were updated based on ingredients.

The other food groups that aren't grain-based but contain grains as ingredients were also affected by the addition of folic acid. In Dairy and Egg Products there was a cheese fondue that contained flour. In Baby Foods, dinners with pasta, cookies, pretzels and zwieback used enriched flour. In dinners with rice, unenriched rice is used so there were no changes needed. In Soups, Sauces, and Gravies, soups containing pasta, white sauces and gravies had to be updated. However, rice soups used unenriched rice and did not have to be updated. Vegetables and Vegetable Products had a few vegetables that were breaded or had a sauce containing flour. In Legumes and Legume Products, falafel contained flour. In the Beverages food group the only item affected was the orange-flavored breakfast type drink that no longer has folic acid added.

When we met to discuss the changes required for the database because of the addition of folic acid to grain products, our staff working with meat products thought they would not be involved. However, Poultry and Poultry Products, Finfish and Shellfish Products, and Lamb, Veal, and Game food groups all had battered or breaded and fried products that contained enriched flour as an ingredient. Using the formulation for the

amount of flour and meat with a retention factor the folate values were calculated for these products.

Examples of folate values in foods from various food groups before and after the addition of folic acid to enriched grain products are given in Table 5.

In addition to the implication the regulation had for the 1998 release of Standard Reference, the USDA Continuing Survey of Food Intakes by Individuals (CSFII) was in the field during 1996 (USDA 1998a). The Nutrient Data Laboratory develops the Primary Nutrient Data Set that is used to create The Survey Nutrient Database. The question was, should enriched folate values be used for calculating nutrient intakes for the last year of the 1994-1996 CSFII?

The final rule for the addition of folic acid to foods was published March 6, 1996. Although there was almost 2 years before the folic acid had to be added to foods, the problem for the industry was the virtual impossibility of converting food labels at precisely the same time the folic acid was added to the product formulation. The National Pasta Association submitted a request to FDA to permit folic acid addition to products without requiring declaration in the ingredient statement. In September of 1996 the FDA published in the Federal Register a clarification of the March, 1996 Amendment of Standards of Identity for Enriched Grain Products to Require the Addition of Folic Acid (FDAc). FDA stated, “To facilitate initiation of fortification for firms who voluntarily fortify foods in a manner consistent with the new folic acid fortification requirements, the agency is unlikely to enforce the ingredient declaration and nutrition labeling requirements of the Federal Food, Drug, and Cosmetics Act with respect to this nutrient until after January 1, 1998.” This meant that companies could add folic acid to their products without having them declared in the ingredient list or on the nutrition panel, as long as they didn’t make a health claim.

When this statement was published in September, many companies which were delaying folate fortification because of fear of FDA action if their labels were not correct, began requesting that their suppliers include folic acid in future shipments of grain ingredients. During the last 3-4 months of 1996 the amount of product on the market with added folic acid was changing. One recommendation we got was to change the folate values for all breads, rolls, buns, cakes, flour, and pasta in the database to include the added folic acid. We knew this would be an overestimation of the folate in foods, because although many companies were in the process of adding the folic acid to their products, it would be sometime in 1997 before all of their products had the added folic acid. It was impossible to determine the percentage of products on the market with added folic acid. The decision was made not to use enriched folate values for the 1996 CSFII.

Fortunately, the Food Surveys Research Group didn’t have a survey in the field during

1997 when the number of products on the market with added folic acid was increasing rapidly. The Supplemental Children's Survey went into the field during the middle of December, 1997; data collection will continue through November of 1998. Enriched folate values will be used for this Survey.

We used the folate levels specified in the regulation for the enriched grains and calculated the folate values for products in which they are ingredients, in order to be able to release a database early in 1998 that would reflect the changes in regulations. We know that these calculated values will need to replaced with analytical values. Using the Key Foods process (Haytowitz et al 1996), the ingredient foods that were the major contributors of folate to the U.S. diet before the regulation were pinto beans, lettuce, orange juice, eggs, rolls, tea, corn flakes, instant oatmeal, Frosted Flakes, and white bread. Using the revised database to determine the Key Foods for folate, now the major contributors of folate are rolls, all-purpose wheat flour, white rice, spaghetti, pinto beans, white bread, macaroni, lettuce, orange juice, and eggs. As expected the enriched grain products have replaced many of the foods that have only naturally occurring folate and the breakfast cereals that are fortified at the lower level . These are the foods that we will target first for analyses.

The documentation for Standard Reference (USDA 1998b) identifies the method for analytical values as a microbiological method using conjugase and Lactobacillus casei. It also cites an article by Beecher and Matthews published in 1990 that reported that methodology for folate is lacking, needing improvement in the areas of method development, extraction procedures and applications.

In the Third Report on Nutrition Monitoring in the United States, published in 1995 (LSRO 1995), there is a table on the Evaluation of Assay Methods and Quality of Food Composition Data for Use in Assessing Dietary Intakes of Nutrients. For folate the rating of the assay method is conflicting; the rating of data quality is variable. In the comment field it stated, "Recent finding suggest that traditional assay methods are not acceptable for the assay of complex foods and mixed dishes. This is a very controversial area. Research is needed on the development and validation of the methodology." Elsewhere in the report folate was identified as, "Potential public health issues for which further study is required." The last sentence of that discussion stated, "Improved methodology for analyzing folate in food and blood samples is the most critical need for the further study of folate."

Logistically, improvements in methodology will always have to precede improvements in nutrient composition data. We are encouraged that there is progress being made toward an official method and hope the standardization and optimization of the method that are still needed will come quickly.

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Table 1. Folate Levels Required for Enriched Grain Products

Enriched Grain Products	Folate	
	mg/lb	:g/lb
Flour	0.7	154
Cornmeal, Grits	0.7 - 1.0	154 - 220
Farina	0.7 - 0.87	154 - 192
Rice	0.7 - 1.4	154 - 309
Macaroni, Noodles	0.9 - 1.2	198 - 265
Bread, Rolls, Buns	0.43	95

Table 2. Revised Folate Values for Enriched Grain Products

Enriched Grain Products	Value Before Folic Acid Added (:g/100g)	Value After Folic Acid Added (:g/100g)
Flour	26	154
Cornmeal, Grits	48	187
Farina	24	173
Rice	8	231
Macaroni, Noodles	18,29	231
Bread, Rolls, Buns	34, 30, 27	95

Table 3. Formulation for Biscuit, Plain or Buttermilk, Commercially Baked

Ingredients	Percent
*Wheat Flour, All-Purpose, Enriched	54.2
Water	19.5
Soybean Oil	15.9
High Fructose Corn Syrup Solids	6.1
Baking Powder	0.9
Baking Soda	0.9
*Buttermilk, Dried	0.9
Salt	0.9
*Non-Fat Dry Milk	0.9

*Ingredient that contributes to the folate content of the product

Table 4. Calculating Folate Content from Ingredients

Ingredient	%		Folate		Retention Factor %		Total
Flour, All-Purpose, Enriched	54.2	X	154	X	70	=	58.4
Buttermilk, Dried	0.9	X	47	X	85	=	0.4
Non-Fat Dry Milk	0.9	X	50	X	85	=	0.4
							59.2

Table 5. Folate Values for Selected Foods Before and After the Addition of Folic Acid

Food Item	Folate Value (:g/100 g)	
	Before	After
Biscuit with Sausage	7	37
Chicken Leg, Fried, Batter Coated	9	18
Chicken Noodle Soup, Condensed	2	16
Coffeecake	32	61
Hamburger Sandwich	28	59
Onion Rings, Breaded	19	48
Orange-flavor Breakfast Type Drink Powder	483	0
Pretzel	83	171

OVERVIEW: NORAMFOODS, THE INFOODS REGIONAL DATA CENTER FOR NORTH AMERICA

Barbara Burlingame, INFOODS Coordinator, c/o NZ Institute for Crop & Food Research, Palmerston North, New Zealand.

When INFOODS was created in 1983, one of its goals was to establish regional data centers around the world, to improve the quality and quantity of food composition data, especially in developing countries; and to enhance and encourage development of standards, harmonisation efforts, and interchange of food composition data. Most countries in the world are now part of a regional data centre. The country by country association with regional data centres is determined by those countries, and can be based on common culture, language, geographic proximity or trading bloc agreements.

The UNU/FAO/INFOODS regional data centre for North America -- NORAMFOODS -- is now firmly in place. A structure for NORAMFOODS, proposed at the first meeting held in February 1995, was formalised at the second meeting held in September 1996. A third meeting was held in July 1997 to review activities, progress and problems. NORAMFOODS is made up of representatives of Canada, Mexico, and the United States. In addition, the Mexican National Food Composition Data Center (MEXFOODS) coordinates a network for the Spanish and French speaking countries of the Caribbean, known as MEXCARIBEFOODS. The English-speaking countries of the Caribbean are covered by a regional data center in Jamaica, known as CARICOMFOODS. Representatives of MEXCARIBEFOODS and CARICOMFOODS will continue to be represented at all NORAMFOODS meetings. Among the decisions taken was that six working groups would be necessary in order to achieve harmonisation in food composition data sets prepared in the different countries. These proposed working groups include: recipe standardization; food terminology and nomenclature; analytical methods and quality control; data quality identification; statistical issues; and industrial ingredients data base. The first of these will be coordinated by Miriam Chavez of MEXFOODS, the second by Danielle Brulé of CANADAFOODS and the remaining four by USDA personnel. MEXFOODS and NORAMFOODS are already using INFOODS tagnames which facilitate data interchange within the INFOODS system. Both CARICOMFOODS and CANADAFOODS will incorporate tagnames in their data bases as soon as possible. Joanne Holden was elected coordinator of NORAMFOODS for a two-year term.

The panel discussion at the end of this session will help the NORAMFOODS coordinator, each country*s coordinator, and each of you who is active in food composition work, to see how your work plans, on-going research and food composition projects can serve the goal of achieving more and better food composition data for use for everyone throughout the countries of North America, and beyond.

HARMONIZING NUTRIENT DATABASES FOR NORTH AMERICAN POPULATIONS: THE MEXICAN PERSPECTIVE

Dr. Miriam M. De Chávez, Dr. Adolfo Chávez, Lic. José Angel Ledesma, Dr. Sergio Serna. Instituto Nacional de Cancerologia, Mexico

Mexico was the source of many of the foods that were taken from the American continent to Europe, such as corn, beans, tomato, chile (hot pepper), cacao (cocoa beans), etc. However, it is likely that among all the existing foods, only 10% of the native or autochthonous food products are known internationally. This means that there are tens or even hundreds of mainly fruits and vegetables that are unknown outside Mexico and even outside their micro-region. A project supported by McKnight Foundation is now underway to rescue the germ plasm of vegetables.

Mexico was one of the most important Vavilov centers, a source of many edible species as well as a crossroad of foods at a world level. During 17th and 18th centuries, many foods from Asia were brought to Mexico in the so-called Ship of China -which was in fact the Galleon of the Phillipines- that picked up foods from all over Asia. That is why prior to the Spanish conquest, many foods from the Andean Vavilov center could already be found in Mexico, such as potatoes and foods from the Caribbean tropic, like the yucca and many other roots. Due to the above and to the fact that Mexico has preserved many varieties not only of the native species but also of others that were brought later into it, Mexico becomes especially relevant for the purpose of creating a thorough database.

It is a well known fact that at present the United States and Canada are the source of many of the new industrialized, modified, compound foods and that virtually all of them are reaching Mexico and the Caribbean.

The new food nutritional value tables coordinated by MEXFOODS have already achieved a high degree of harmonization, first with the Spanish-speaking Caribbean countries whose analyses have been included, and, second, with the Central American (INCAP) and United States (Handbook No. 8) Tables. All of these Tables have been consulted by the computer software programmed for the following:

- If very similar results are obtained, it takes the Mexican result,
- If only one result is different, it considers the mean of the remaining results, and
- If all results differ, they are discussed considering other tables and the one that qualifies as the most acceptable one is included.

This information is available for the 800 most consumed foods in Mexico and the Caribbean. The resulting table involves an acceptable level of compatibility, but from the Mexican standpoint. This is both because the 800 selected foods are the most consumed ones in Mexico and because the computer software considered Mexican values as a priority.

At present Mexico has:

- Three printed versions with an average of 800 foods and 37 nutrients
- A computer version of the tables, and
- A multimedia CD-ROM with pictures, latin names and the names of foods in three languages. This volume contains basically fruits and vegetables.

There are advantages and disadvantages to a regional database. The advantages include free regional access to the database and the fact that the countries can share the cost of the analyses, especially of native foods. Some of the disadvantages, which are really of little importance, include the food nomenclature, the languages to be used and deciding how much to charge database users.

In order to achieve integration and harmonization of the regional database we suggest the following:

- That all three countries know exactly each other's data and have free access to each other's databases.
- That food names are given in three languages. Besides the latin name, the common name should appear in English, Spanish and French.

To document food analysis data specifying: the analytical method, the number of samples analyzed, the sampling method and the mean and standard deviation of each analytical value. We suggest to include the following as optional: upper and lower analytical values, sample characteristics, the region where the product is grown, its degree of ripeness, growing conditions, time of harvest, etc.

A list of natural native foods to be prepared by each country and a commitment to analyze them, thus enriching the regional database. Mexico has planned to analyze 150 natural foods in the next two years.

A list of the most widely used traditional recipes (by region) to be prepared by each country and a commitment to analyze them.

To define the foods that are common to all three countries and to use regional borrowed data.

A list of the fresh and industrialized foods that each country exports to other countries in the region and a commitment to make the corresponding chemical analysis to be included in the regional database.

To jointly decide which are the priority nutrients for the region, based on the existing food groups, their known functions and the health problems in the region, as well as the

analytical capacity available in each country.

To take into consideration some special cases such as carotenoids and many other bioactive phytochemicals that are constantly and increasingly being linked to several chronic, non-communicable diseases. This would include the study of isomers.

There are at present 15 laboratories in Mexico involved in the chemical food analysis project. They are located at universities and research centers in different states of the country. Some of them have the necessary equipment to analyze the 37 nutrients included in the Mexican tables. Others work jointly and have distributed among themselves the work of analyzing proximals, amino acids, vitamins and minerals.

As regards the native foods project, we propose to create a work group composed of several universities and organizations of the United States, Canada and Mexico that have resources and technical capacity in the area of food analysis.

The field of foods is a very dynamic one. The population is increasingly motivated to consume new and, mostly, better foods. Agriculture and industrial firms are ready to produce and offer an enhanced variety of foods. This means that we will have many new products to analyze every year, which may be more or less healthy, depending on the outcome of our participation. We may state with certainty that in the region composed of Mexico and the Caribbean countries there are still many more new foods that will allow us to achieve a better population health and a stronger economy that may also benefit other regional common market countries.

To close, we would like to express a warning regarding the great number of plant species and varieties that could disappear in the near future without us having ever known about their nutritional value. Let us rescue the many endangered fruits and vegetables that may represent a true treasure of bioactive phytochemicals.

HARMONIZING NUTRIENT DATABASES FOR NORTH AMERICAN POPULATIONS: THE CANADIAN PERSPECTIVE

Danielle Brulé, Section Head and Josie Deeks, Nutrition Officer, Nutrition Survey Section, Food Directorate, Health Canada, Ottawa, K1A 0L2

The Canadian Nutrient File (CNF) is a computerized database of food nutrient values currently in use in Canada. It is derived from the USDA Handbook No. 8. Modifications take into account the Canadian food supply, Canadian practices, grading standards, and some uniquely Canadian foods. The decision to maintain a Canadian standard reference came about because the major source of nutrient data for the Nutrition Canada Survey, conducted in the early seventies, was the 1963 USDA Handbook No. 8 : we wanted a database that included uniquely Canadian foods for use with our survey data. Also, a large number of different databases had begun to emerge in Canada and it was felt that one standard reference would eliminate the resultant variations in the quality of nutrient data. Eight versions of the CNF have been compiled and released since its implementation in 1979. The current edition of the CNF was released in April of 1997.

General Features

In keeping with our Canadian character, the CNF is bilingual and metric. Thus, all food names, nutrient names, and measure descriptions are in French and English. All conversion factors and measures are in metric system equivalents. Both the source of the analysed food and the source of the mean value for each nutrient are indicated by numerical reference source codes.

Over the past year we have been developing a new in-house software program for the compilation of the CNF. This new system is in a Windows-Oracle environment allowing editing, archiving and potential for additional fields.

Food Name File

The 1997 version of the CNF lists nutrient values for 4668 foods commonly consumed by Canadians. The new software allows us to maintain two fields for food descriptions. The first is limited to 60 characters and contains some abbreviations. The second is an expanded food name with no abbreviations as well as room for more natural phrasing (ie “prepared from mix with added milk and egg” rather than “incomplete”). A systematic nomenclature is used for structuring these food names. Elements which may be included are group, product, type, part, physical state, shape or form, cooking method, preservation method and/or brand name. Food names are in both French and English.

Each food can also be referred to by a sequence number unique to our database as

well as an eight digit food code (similar to the USDA food codes) which reveals the group to which this food belongs, the source of the data and an assigned item number.

To demonstrate some of the features of the in-house data management software and the CNF database itself, the next slides display the data entry screen, as it appears to the compiler. The first slide shows the information contained in the food name file. In the uppermost corner, we have the sequence number, followed by the group, source and item numbers for this food. We have also added a Country code box, into which we would place the foodcode used by the country from which the primary data originated. In this case it is empty because Canadian manufacturer provided the data. The next field is the 60 character food name in English and French and the expanded food names below.

Nutrient Name File

The nutrient name subfile lists 115 different components in English and French, abbreviations for each nutrient, their respective codes, and units of measure. The 3 digit nutrient codes match those of the USDA Nutrient Database for Standard Reference. We do not at this time list INFOODS tagnames, but a new field for this purpose can easily be added.

Nutrient Amount File

The largest of the three files that make up the database lists the values for each nutrient within a food. The in-house data management software allows us to archive all changes to the nutrient data, and view the archived value using the same search mechanism used for current data. All record modifications are accompanied by a date of entry. Missing values are readily distinguished from real zeros by an indicator in the far left column of the data entry screen.

This slide shows the entire data entry screen. Note the different folders for data archiving, measures, refuse, etc. Also note the missing value indicator, date of entry, and fields which allow us to record additional information on method of analysis, source of legislation regarding this nutrient or the reference from which this value was obtained.

Advantages

Each of the contributing countries involved in NORAMFOODS maintains food composition data that relates to the food supply of their own population. The CNF is designed to provide nutrient values for basic foods and simple recipes commonly consumed in Canada. This allows us to prioritize food and nutrient analyses to our

specific needs and to appropriately distribute resources. However, our market is continuously expanding and changing and we cannot keep up with the vast array of new products or the changes in current product formulations. We frequently receive requests for information on these foods so time is spent searching for existing data, evaluating data quality and converting data to standard units. A regional database with a recognized structure may yield fast and easy access from a larger pool of nutrient data. In addition, we could expect an established standard approach to the assessment of data quality.

With the enlarged opportunities for communication and collaboration that this project provides we would not only benefit from sharing nutrient data, but also from sharing expertise and experience. Duplication of effort can be avoided in such areas as method development, data formatting and nutrient analysis. Collaboration on resolving common problems would be more effective. Of special importance is the development of standard guidelines for data gathering, formatting and documentation.

Beyond advantages to the development of each contributing database, participation in the development of the regional database offers the opportunity to play a role in establishing effective, reliable food composition data in developing countries. This process is crucial to the formulation of improved nutrition programs and policy. Even in our own countries the impact of food composition data on the health of populations is not as well recognized as it should be. The larger scope of NORAMFOODS may more effectively target government officials and funding agencies.

Harmonization Issues

There are a number of issues which must be addressed in order to secure Canadian involvement in the implementation of the NORAMFOODS, regional data centre. First, Copyright in any Canadian government publication automatically vests in the Federal Government. As a result of this, we are obliged to charge a fee to all clients requesting the CNF. We are currently investigating the legal implications and client reaction to providing this same data as part of the NORAMFOODS database.

Within Health Canada, the current budget for the CNF allows for one full time employee. The present workload already exceeds the available manpower. Priority projects are backlogged. Efforts must be made to secure more resources on a more permanent basis.

This last point on the slide has been mentioned before and some progress is being made toward merging the various datasets. However, there is still much work to be done with regard to compatibility of measure descriptions, use of graphic images, field lengths, field names, etc.

Next Steps

As mentioned previously there are clearly instances where identical data is required by different parties. For example, because of the limited number of producers and buyers as well as extensive cross border distribution, the Canadian and US Bison Associations have demonstrated that it is possible to combine nutrient data from both countries and avoid duplication of time and effort.

The various working groups cannot be expected to make much headway without more frequent meetings and opportunities to communicate than have been made available up until the present time. We look forward to scheduling regular meetings and working on the continued development of the harmonization of nutrient data and expertise between the participating countries.

HARMONIZING NUTRIENT DATABASES FOR NORTH AMERICAN POPULATIONS: THE CARIBBEAN PERSPECTIVE

Pauline M. Samuda, Caribbean Food and Nutrition Institute

The development of a comprehensive nutrient database for the Caribbean region presents a major opportunity to promote public health and foster food trade within and outside the region. Eighteen countries, separated by large expanses of water and spanning a distance of nearly 4,000 km comprise member countries of the Caribbean Food and Nutrition Institute (CFNI). The dietary practices of the region reflect the diverse heritage of its people (African, Asian, Amerindian, European).

Information on the nutrient content of approximately 900 foods commonly consumed throughout the Caribbean are published in the second edition of the Food Composition Tables for use in the English-speaking Caribbean (CFNI, 1995). The first edition, published in 1974, contained data on 668 foods (CFNI, 1974).

In these tables the food composition data are presented in 15 food categories adapted from those suggested by the FAO of the United Nations for reporting food consumption surveys or compilation of food balance sheets. Table 1 shows the number of entries by food categories.

Food items for which compositional data are provided are those commonly found in municipal and parish markets and supermarkets throughout the English-speaking Caribbean as well as from information provided by the Agricultural Statistical reports published by different governments in the region.

Food components addressed are: Moisture, Energy, Protein, Total Fat, Saturated Fat, Cholesterol, Total Carbohydrate, Fibre (only crude fibre values for some entries), Calcium, Iron, Potassium, Sodium, Zinc, Vitamin A, Thiamin, Riboflavin, Niacin, Total Folacin, Cyanocobalamin and Vitamin C. Data were drawn predominantly from international data bases including the USDA handbook 8 and the British food tables. Although there are some data for cooked and processed foods, most of the data are for the edible portions of raw foods expressed as nutrient weight per 100 gram edible portion. Also included are percentages for refuse, as purchased. To date, tag names and descriptors have not been attached to the food components.

Two major activities, aimed at updating food composition information for the Caribbean, were recently carried out by the Caribbean Food and Nutrition Institute. First, a “Core foods” list was identified for Jamaica through a study conducted in collaboration with the University of Maine, USA. Using the national sampling protocol developed in that study, samples of 24 of the 70 identified foods/dishes were collected and analyzed for proximate constituents, dietary fibre, lipid content and 11 minerals.

Table 1: Number of Entries by Food Categories Contained in the Caribbean Food Composition Tables

Food Category	Number of Entries
1. Cereals	111
2. Starchy Fruits, Roots and Tubers (Ground Provisions/Produce)	36
3. Sugars and Syrups	27
4. Pulses Nuts and Oil Seeds	75
5. Green Leafy and Yellow Vegetables	84
6. Other Vegetables	53
7. Fruits	90
8. Meats	81
9. Poultry and Other Meats	30
10. Eggs	10
11. Fish and Shellfish	98
12. Milk and Milk Products	46
13. Fats and Oils	32
14. Miscellaneous Foods	64
15. Composite Dishes/Prepared Foods	64
TOTAL	**901**

Second, the Nutritionist IV dietary analysis programme, used for evaluating dietary studies in the region, was modified from its predominantly United States database to include approximately 1,000 Caribbean (mostly Jamaican and Trinidadian) foods. Nutrient data for the Caribbean foods entered into the database include some direct analytical data and manufacturers' product data but are mostly those derived from nutrient content calculations of popular recipes collected from some Caribbean islands.

Notwithstanding all these efforts, the current Caribbean food tables are characterized by two major limitations, namely:

1. The incompleteness of the nutrient profiles of foods especially with regards to lipids, minerals and dietary fibre.

2. The discernible absence of data on a number of foods commonly consumed by peoples of the Caribbean as well as data on composite dishes prepared by traditional cooking procedures.

These limitations present major obstacles to the assessment of dietary intake studies and have resulted in the absence of authentic food consumption studies in member countries. Furthermore, users of food composition data within the Caribbean such as government agencies, policy makers, health and agriculture professionals and consumers have consistently expressed the need for updated and extended food composition data.

Responding to the needs of the region for updated and expanded food composition data, CFNI is now embarking on the task of establishing a regional nutrient data base to be called CARICOMFOODS. This move is in line with the goal of INFOODS to create regional food composition centers with the goals of encouraging the generation of food composition data and developing an easy and accurate interchange of food composition data among countries and regions (Rand and Young, 1984). It must be noted that although INFOODS was initiated over a decade ago, the Caribbean, due largely to lack of financial and technical resources, remains one of the few regions in the world without the structure firmly in place for a data center.

CARICOMFOODS is expected to fulfill two major objectives, namely:

1. The generation and compilation of food composition data on foods and food products consumed by Caribbean populations, and;
2. The computerization of the food composition data structured in a form which offers conformity with the INFOODS system and which will promote regional and international access to Caribbean food composition data.

To fully establish CARICOMFOODS, CFNI has developed a proposal which seeks funds to implement the planned activities. Chief among the priority activities are the development of:

1. Standards and guidelines for the collection, compilation and reporting of food component data.
2. A food analysis network to facilitate the generation of food composition data and interlaboratory trials.

3. Sampling protocol to achieve representativeness of Caribbean foods.
4. Descriptors for single and mixed foods.
5. Guidelines for computerizing the database:
   - Formatting
   - Structure of files
   - Import and export of data
   - Movement of data files between Caribbean countries

It is proposed that CARICOMFOODS form a branch of NORAMFOODS regional data center.

The linkage of CARICOMFOODS to NORAMFOODS offers several potential advantages:

1. NORAMFOODS with its already functional system could offer valuable guidance to the development of CARICOMFOODS.
2. Caribbean migrant populations distributed throughout North America continue to consume many foods, food products and dishes unique to the Caribbean region. CARICOMFOODS linked to NORAMFOODS would offer easy access to Caribbean food composition data to governments and private agencies involved in the investigation of diet and health relationships of ethnic groups.
3. Caribbean governments have recently endorsed the World Trade Organization's agreement governing international trading practices. The implication of this agreement is that the region will be involved in more extensive trading in food among countries such as the U.S., Canada and Mexico. Linked data base between the two regions would offer interactive access to a wider range of food composition data.

Possible disadvantages of the linking of the two systems are related to the issues of intellectual property and ownership of access fees.

The successful establishment of CARICOMFOODS will therefore fill a huge vacuum which is hindering the development of various food and nutrition programmer in the region. We hope that the new millennium will coincide with the launching of our nutrient database in the Caribbean.

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Capstone Presentation – 22nd National Nutrient Databank Conference: EMERGING ISSUES FOR THE NEXT GENERATION OF DATABASES

Jean A.T. Pennington, PhD, RD. Division of Nutrition Research Coordination, National Institutes of Health, Bethesda, MD

It is encouraging to look back over the past 23 years and consider how much progress has been made in our knowledge and understanding of the many components of foods and their associations with health and disease. The computer systems we have today have certainly improved since 1975 with increased storage capacity and speed of response. The food values have also improved, but at a slower rate, one food at a time and one food component at a time. It is difficult to "see" the improvements in food composition databases because the documentation of the analytical methods and sampling designs and the treatment of the resulting data on many analytical samples are not apparent in the data tables or computer disks that hold the summarized information. We often note that trust in the validity and representative nature of the data seem be related to one's knowledge of how data are collected, compiled, and summarized. Those who know little about food composition data tend to have more faith in the data, while those who understand the difficulties in this area of research are more conservative in their assessments. Those who use the data appropriately, knowing the potential weaknesses of the data are more likely to draw reasonable conclusions from analysis of dietary intakes.

This 22nd Conference has helped us to think about a number of different issues regarding food composition databases. I would like to highlight six of them:

The **National Food and Nutrient Analysis Program**, addressed by Joanne Holden and developed by Joanne and by Dr. Abby Ershow of the National Institutes of Health, has reminded us of the importance of routine analysis for maintaining and updating our national and other databases. The composition of our foods changes and evolves over time as new foods or formulations become available; analytical techniques and methods to determine the levels of food components become more accurate and reliable; sampling schemes become better designed to ensure representative samples; and we learn more about food components that are important to human health. Information on food composition is the basis for all research work on the relationships between diet, health, and disease. As stated in previous Databank Conferences, the National Nutrient Database is a US treasure and it should be treated as such. Perhaps one of the outcomes of this and future Databank Conferences might be to find ways to encourage Congress to provide the needed funding for this most important work.

The **harmonizing of databases in North America**, as discussed by representatives from Mexico, Canada, and the Caribbean, is an exciting and intriguing venture. How enriching it would be to combine the resources and expertise of Canada, Mexico, the Caribbean, and the US to develop a single database or perhaps four databases that

are compatible, i.e., that use same format, computer software, food names and descriptors, nutrient names, and nutrient data. Food trade flows easily among these four countries. Much US produce comes from Mexico. The cuisine of Southwestern States is based on many Mexican or Southwestern foods such as red and green chilies, posole, tortillas, fry bread, burritos, enchiladas, flan, and mole. Many of these foods, although widely consumed in the US, are not in the National Nutrient Database. Foods consumed in Canada are basically the same as those in the US, and there is much food trade between these two countries. We need to find better ways to exchange, share, and document our food composition data among North American countries. If the US, Mexico, Canada, and the Caribbean could find ways to share knowledge and resources regarding food composition databases, perhaps the government funding agencies in these countries would be more inclined to increase resources to develop and maintain nutrient databases.

The work on **folic acid databases,** presented by Dr. Jesse Gregory, Dr. Jeanne Rader, and Sue Gebhardt, gives us hope for revised estimates of the dietary intake of this vitamin. Data on the folic acid content of foods is confounded by the labile nature of this vitamin (i.e., its sensitivity to oxidation); the different forms of the vitamin with different biological activities; its easy destruction during food storage, processing, and cooking; its destruction during laboratory analysis; and the difficulties of the microbiological assay used to determine it presence in foods. With the FDA's 1998 requirement for fortification of grain products with folic acid, there are additional challenges for food composition database users and developers. Considering all the grain and grain-based products that are to be affected by folic acid fortification, we must resolve to update the folic acid values for these products in our databases. It is exciting to consider the potential health effects of folic acid fortification on birth outcomes. This will be an important area of research, and it will necessitate that accurate information on dietary intake of folic acid be available.

The topic of **databases for dietary supplements**, presented by Margaret McDowell, has long loomed over the heads of database developers and users. The enormity of the task has caused us to largely ignore it, i.e., to calculate nutrient intakes from foods and not to include nutrients from supplements. It is time for us to face up to the contribution of dietary supplements to the total nutrient intakes of population groups. Supplement databases are continuously moving targets with thousands of different commercial products. The levels of nutrients in dietary supplements can easily overwhelm nutrients from foods, and the use of supplements is widespread and variable in terms of the types of supplements that are used and the frequency of their use. Margaret has provided us with the basics about how a database of this nature can be compiled and maintained. When dietary supplement databases become fully developed, researchers will have the opportunity to understand the effects of dietary supplements on nutrient intakes. Perhaps our inability to create and maintain a supplement database and to obtain information on supplement intake from survey

participants is one reason why we see so little direct connection between diet and biochemical measures of health status. It is essential that we be able to separate the populations we evaluate into users and non-users of dietary supplements to begin to make sense of diet, health, and disease relationships.

We are just at the beginning of our understanding of the biochemical and physiological roles of **botanicals and herbal preparations** on human health. This topic, presented by Dr. Bernadette Marriott, is still one of mystique as the extent of use and reasons for use of botanicals and herbal preparations are not well known. Botanicals and herbal preparations include both natural (i.e., raw plants or plant parts) products and brand-named products with mixed and/or processed ingredients. In some respects, botanicals and herbal preparations seem to be at the merging point of foods and drugs. Bernadette has indicated that botanicals and herbal preparations are more like supplements than foods in terms of their form and how they are consumed. Do we need separate database for botanicals and herbs or could they perhaps be merged with dietary supplement databases? What is the composition of these products and do they overwhelm nutrient intake like dietary supplements do? We have similar concerns about how to deal with drugs that contain nutrients (e.g., calcium and magnesium in antacids)? Should all products containing nutrients or other food components be in one database and allow the user to separate foods, supplements, botanicals, herbs, and drugs if they desire to do so? The different products could be coded into these categories, and database users could chose to evaluate the nutrient contributions from these sources together or separately.

We have had presentations on flavonoids and carotenoids at previous Database Conferences (Buffalo, NY in 1995 and Baton Rouge, LA in 1996). At this meeting we have heard about **flavonoids, phytoestrogens, and carotenoids** from Dr. Gary Beecher and David Haytowitz. We seem to be on a voyage of discovery with functional components in foods as their relationships to chronic diseases are uncovered. These compounds are attracting the interest of medical professionals and consumers. The challenge with these compounds is to consider all the different chemical compounds with different biological activities that fall within the definitions of these three types of compounds. Flavonoids alone constitute some 4,000 compounds, some with no apparent biological activity and others with activity related to vascular function, cancer, and/or the immune system. How can we add these compounds to our databases in meaningful ways? Perhaps it is useful to keep these compounds in separate databases until we have more information on their locations and levels in foods and of their physiological effects and actions.

Lessons Learned from National Nutrient Databank Conferences. Databank Conferences serve as forums to share and exchange information about food composition databases. The primary goal of the Conferences is to improve the quality, quantity, and availability of data on the levels of food components in foods. The issues

presented at this conference will take several years of work to resolve. The concerns and problems of our current databases will be solved little by little just as they have for previous databases. We will continue to learn about the complexities of food composition, including naturally-existing components and components that are added to the food supply through agricultural and manufacturing processes and through contamination. Reflecting on the topics and issues of our Conferences over the past 23 years, I think that we have gained some important knowledge:

First, no matter how much we might like to separate food composition data and food consumption data, they are intimately linked. Most database compilers build and design databases to evaluate food and nutrient intake data from food consumption surveys, from diet-related research studies, or from individual patients and clients. The decisions we make about food composition databases affect the nature of the questions that can be asked in food consumption surveys and studies. Similarly, the questions asked about food intake in dietary surveys affect the structure of the database and detail of the food descriptions.

Secondly, as we make decisions and assumptions regarding food composition and food consumption data, we have learned to consider the magnitude of errors that might be introduced. In general, errors in food intake information are far greater than errors in food composition, even when nutrient values for foods are calculated from recipes or imputed. Accurate and reliable food composition data will not yield accurate and reliable dietary intake information if the food composition data are merged with questionable data on food intake.

Third, we now know that the variability of a food component in a food is a reflection of the biological or chemical composition of the materials that we choose to consume as food. (Although some variability between laboratories and analysts may be due to analytical “differences” and not reflect “natural” variability.) Each food component in each food has a variability around the mean value. The variability may be inherent (i.e., due to species characteristics or the age/maturity of the plant or animal tissue), or the variability may be derived from environmental (e.g., due to characteristics related to soil, climate, rainfall, or pesticide application) or processing (e.g., due to cooking methods or food additives) factors. Variability of the levels of food components in foods can and should be measured. Sometimes variability in nutrient values is an important clue telling use that we have a mixed sample. Further investigation may reveal that we need to separate cultivars or separate brand names of the same product. We have yet to determine how to express variability in meaningful ways in food composition databases, and we don’t yet know how to use variability in food composition when we assess daily nutrient intakes.

Fourth, it is difficult for database compilers with backgrounds in nutrition and foods to also be experts in computers and statistics. Therefore, the development of food

composition databases usually requires a collaborative effort among individuals with expertise in these areas (nutrition, foods, computers, and statistics). If we can clearly communicate our needs and expectations for the database to our computer and statistical experts, we are more likely to end up with databases that serve our purposes.

Other Lessons. You can also learn a lot about food composition databases if you attempt to compile one. Many attendees of Nutrient Databank Conferences have database development experience. You learn that the development of food composition data is slow (i.e., requires years) and complex; you must wait for data to appear in the literature. The researchers who want new analytical data must find funding; decide on the foods to be analyzed and the food components to be determined; design a sampling scheme; buy, transport, prepare, and store the foods; find chemists with fully-equipped, modern laboratories; find suitable analytical methods for the food components of interest; determine the statistical strategies for the analytical values that result; document every step of the process; and then write the papers, submit them for clearance and review, and get them published.

If you are also compiling data from food companies and restaurants, you know that the process is also slow and often not productive. You must send letters, call, wait for response, and then try to discern if what you have received reflects analytical data or labeling values. Sometimes you can't get "real" (i.e., non-labeling) data. You must also try to discern what the foods are as industry food names are mostly fanciful and not descriptive. (Consider the names of many ready-to-eat breakfast cereals, candy bars, snack cakes, commercial entrees, fast-food hamburgers, etc.) The response rate for data from food companies (unless you have a friend there) can be low and slow.

By contrast, advances in computer hardware and software move at the speed of light. By the time you have food composition values to put into your database, you may find that the system you had intended to use has become a dinosaur. The lessons learned by database compilers are to be flexible, expect change, and try not to buy into something that can't be updated. Each time you update your database (if you do it at periodic intervals rather than on a routine basis), you will find that the process is different, but not necessarily improved. It is always tedious and requires a special personality type, i.e., someone who is able to deal with minutiae. You will probably also find that you have to work with a new statistician and a new computer expert and that all your contacts at food companies have moved on to other jobs.

There is no doubt that we are making progress on all the issues presented here today. The Databank Conference this year has clearly dealt with very timely and important issues, and I commend Dr. Suzanne Murphy and Dr. Molly Kretsch for the direction of the Conference and for all their efforts in organizing it. I look forward to next year's meeting to see what progress has been made and what new challenges wait for us.

ESTIMATION OF NUTRIENT CONTENT OF RAW FRUITS AND VEGETABLES JUICES EMERGING AS NEW FAST FOODS. B.J. McCabe, PhD, RD, LD. University of Arkansas for Medical Sciences, Little Rock, AR and Nutrition Matters, Little Rock, AR

A recent review article on the relationship between vegetable and fruit consumption and risk of cancer cited 206 human epidemiologic and 22 animal studies as consistent for the protective effect of fruits and vegetables for eight cancer types. Raw vegetables were most frequently cited as protective. As public awareness increases, a new type of fast food is emerging in the form of juices prepared on the premise from raw fruits and vegetables. These juices are being sold from vendor carts, from juice bars located within health food stores, and more recently from independent stores. Dietitians face lack of accurate data on nutrient content of fresh juices, especially 'raw' vegetable juices. Nutrient databanks contain values for some canned vegetables juices but not for "raw". A process by which nutrient content of these juices could be estimated using the gram weight of the raw vegetable or fruit and outcome volume measure in milliliters was tested. Food Intake Analysis System (FIAS3, version 3.0) software was used to estimate nutrient content of three fresh vegetable juices, eight fresh fruit juices, and three mixed fruit and vegetable juices. Juice Works® provided equipment, recipes, and ingredients. While many fresh juice bars provide nutrient information and claims, the procedures may not be standardized. This study contributes both a standardized procedure and nutrient estimates using a research quality software program.

MINNESOTA NUTRITION DATA SYSTEM FOR RESEARCH. JH Himes, G Weil, J Ditter-Johnson, P Goldstein, M Stevens, N Van Heel, AL Eldridge. Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN.

The Nutrition Coordinating Center (NCC) has re-designed the Minnesota Nutrition Data System (NDS) to provide a Windows-based interview system for dietary data collection in research settings. The NDS program, a computerized dietary assessment tool provided by NCC since 1988, incorporates standardized interview prompts and multiple pass data collection methods, and uses one of the most valid, reliable, and comprehensive food and nutrient databases available in the United States. The NCC food and nutrient databases have been continuously updated and expanded to add nutrients of scientific interest and to reflect marketplace changes. However, there have been few substantive changes in the interview program itself. The new Nutrition Data System for Research, version 4.0, provides a Windows-based interface that is graphical and intuitive and follows industry standard. Enhancements increase adaptability, usability, and flexibility for the data collection and management process. The program performs sophisticated food search operations and allows user-defined recipes to be inserted for use in dietary data collection. Collected data are written to output files that support statistical analysis for research purposes. Enhanced reporting capabilities and improved tracking of dietary records facilitate data management and statistical analysis. The program was developed using PowerBuilder 5.1 and S-Designor with Structured Query Language for its database engine. Supported by NHLBI Contract N01-HV-48140.

SOURCES OF CALCIUM IN THE U.S.: FOOD vs. SUPPLEMENTS vs. WATER.

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Currently available U.S. population estimates of calcium (Ca) intakes are largely based on food intake only and do not include Ca intakes from vitamin/mineral supplements (SUP) or water. Supplement use is widespread in the U.S. and water can be a source of Ca, particularly in hard water areas. Using individual intakes of food and drinking water, and frequency and types of SUP use from the 1989-91 USDA Continuing Survey of Food Intakes by Individuals, potency of SUP from the 1986 National Health Interview Survey and label directions for daily dosage, and median Ca content of finished ground water from the 1989-92 survey of the American Water Works Association, we estimated Ca intakes from food+SUP+drinking water by 4 age/sex groups of adults in the East North Central region of the U.S. To these estimates, we added estimates of Ca intakes from the water used in food preparation (recipe water) to determine Ca intakes from food+SUP+total water. The results showed that about 70 to 85% of mean Ca intakes came from food, 2 to 13% from SUP, and 12 to 18% from water. Recipe water contributed almost as much to the Ca intake from water as drinking water. Supplements increased mean Ca intakes by about 2 to 20% above the intakes from food only. Water increased mean Ca intakes by about 15 to 20% above the intakes from food+SUP. Supplements increased upper percentile intakes of older women the most. Water, on the other hand, increased Ca intakes of people in the lower percentiles the most, regardless of age or sex. The findings of this study underscore the importance of including Ca intakes from SUP and water (especially in hard water areas) in estimating Ca intakes of the U.S. population.

NUTRIENT DATABASE FOR USA MILITARY OPERATIONAL RATIONS

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The purpose of this project was to update an earlier military nutrient database and expand it to include dietary fiber, copper, and the saturated, monounsaturated and polyunsaturated fatty acids. The new database provides a nutrient profile on ration components complete for 30 nutrients with no missing values, and is consistent with the nutrients and the units of measure reported in the United States Department of Agriculture survey nutrient data set. Most values in the military nutrient database are derived from chemical analyses of the ration components. Where information is missing, manufacturers' data, values for similar items, and computer analyses of the formulation are utilized to impute nutrients (nonzero values comprise 4% of the values and estimated zeroes make up 12% of the data). The computerized nutrient database is being used to evaluate menus for rations and to support the analysis of food intake data collected during field studies. When utilized for comparison to the USA military standards, data from the current database increase the accuracy of assessing nutritional adequacy.