

DIETARY FIBER IN THE NATIONAL NUTRIENT DATABANK: DATA AND METHODS**Karen W. Andrews, Nutrient Data Laboratory, Agricultural Research Service, U.S.D.A.****ABSTRACT**

The dietary intake of total dietary fiber for adults is 13.2 g/day according to the USDA 1989-1991 Continuing Survey of Food Intakes by Individuals (CSFII). Forty-three percent of the dietary fiber intake comes from grains and predominantly grain mixtures while 27.5% comes from vegetables; 10.1% comes from fruits and 7.2% comes from legumes, nuts and seeds. The dietary fiber data used in the USDA's surveys are generated by the method, AOAC 985.29, an enzymatic-gravimetric method of analysis. Data from contracted analyses, other government agencies, industry, and the scientific literature are reviewed and incorporated when appropriate. New methods of analysis for dietary fiber and related carbohydrate fractions are also evaluated. As clinical and epidemiological research continues to document the positive health effects of foods high in dietary fiber and dietary fiber components, the Nutrient Data Laboratory is making plans to expand its carbohydrate database. The long range goal of the Nutrient Data Laboratory is to compile quality data on individual carbohydrate components and report total carbohydrate by direct analysis. The dietary fiber components that have been identified as immediate priorities are total dietary fiber, soluble dietary fiber and insoluble dietary fiber. The Key Foods (Key Foods include approximately 500 foods which, either by themselves or as part of food mixtures, contribute 80% of the "key" nutrients of public health significance to the U.S. diet) have been identified as priority foods for the analysis of these dietary fiber components.

Introduction

As clinical and epidemiological research continues to document the positive health effects of foods high in dietary fiber and dietary fiber components, the Nutrient Data Laboratory (NDL) is making plans to expand the carbohydrate fractions published in USDA food composition databases. The carbohydrate data published in USDA databases is obtained from USDA contracted analyses, the scientific literature, the food industry and other government agencies. At the 1993 National Nutrient Databank Conference, the paper, "Carbohydrate Data - Present and Future Needs" (1) discussed the replacement of all crude fiber and neutral detergent fiber values with total dietary fiber (TDF) in the National Nutrient Databank for Standard Reference Release 10. (2) At that time, the TDF data used in the USDA database were generated by one method, AOAC 985.29, an enzymatic-gravimetric method of analysis. (3) This paper includes an update on approved TDF methodologies, a discussion of the status of soluble and insoluble dietary fiber data and the current status of fiber data in USDA databases.

Mean Intake of Dietary Fiber

According to the 1989-91 USDA Continuing Survey of Intakes by Individuals (CSFII) (4), women in this country consume an average of 12.3 g of TDF per day and men consume an average of 16.7 g of TDF per day. Although men consumed more fiber than women per day, women showed a slightly higher rate of dietary fiber consumption per 1000 kcal. (8.2 g/1000 kcal vs 7.7 g/1000 kcal). Forty-three percent of the dietary fiber intake was from grains and predominantly grain mixtures while 27.5% was from vegetables; 10.1% from fruits and 7.2% from

legumes, nuts and seeds.

The results from this and other comparable surveys were discussed at a recent workshop at the 1996 Vahouny Fiber Symposium. (5) In order to encourage consumers to increase their consumption of high fiber foods, workshop members proposed that a formal recommendation be made to the National Research Council to establish an RDA (Recommended Daily Allowance) for dietary fiber based on the National Cancer Institute guidelines of 20-35 grams of fiber per day. The members of this workshop also specifically recommended that an RDA not be established for soluble and insoluble fiber because they felt that there is not enough evidence that measurements using current analytical methods can predict physiologic response.

Dietary Fiber Definition

The most accurate definition of dietary fiber is still being debated among researchers in this field. Since the 1970s, the definition that has been generally accepted defines dietary fiber as the remnants of plant residues (polysaccharides and lignin) which are resistant to hydrolysis by human digestive enzymes. (6) In a recent international survey (7), a majority of dietary fiber researchers agreed on the following points:

- The term “dietary fiber” should be preserved.
- The definition of dietary fiber should be based on chemical and physiological perspectives.
- Oligosaccharides that are resistant to human alimentary enzymes should be included in the dietary fiber definition.
- Having a common definition of dietary fiber is important to advance analytical methods.
- Enzymatic-gravimetric methods of analysis are most appropriate for nutrition labeling and quality control research purposes.
- Enzymatic-chemical methods of analysis are most appropriate for nutrition researchers for whom a detailed listing of dietary fiber components is beneficial.

AOAC- Approved Methods for the Analysis of Total Dietary Fiber

As recently as 1992, the only dietary fiber methods approved by AOAC (Association of Analytical Chemists) INTERNATIONAL were two very similar enzymatic-gravimetric methods. There are now five methods that have been approved by AOAC for the analysis of total dietary fiber in foods (3). Table 1 lists the five methods for total dietary fiber and two methods for soluble and insoluble dietary fiber analysis. The original enzymatic-gravimetric method, No. 985.29, was approved first action in 1985 and is known as the “Prosky” method. The additional methods listed below this method are revisions which optimize soluble and insoluble analysis. Method No. 991.43 is similar to the Prosky method, but uses a MES-tris buffer instead of a phosphate buffer to adjust pH. Both of these methods have been recommended by the Food and Drug Administration for compliance with food labeling regulations and have been approved by AOAC for the analysis of soluble and insoluble dietary fiber.

The last three methods in Table 1, numbers 992.16, 993.21 and 994.13, have been approved by AOAC in the last four years. The first of these methods is an enzymatic-gravimetric method that was developed in Canada and is known as the “Mongeau” method. This method determines total fiber by summing the results of a soluble fiber analysis with an insoluble (neutral detergent fiber) analysis.

The second method, Total Dietary Fiber in Foods and Food Products with less than or equal to 2% starch, is a simplification of the Prosky method and is referred to as a non-enzymatic gravimetric method. The starch hydrolysis step is removed from this method which is only applicable for foods that are very low in starch, such as most fruits and vegetables. This method only determines total dietary fiber content.

The last method listed in Table 1, known as the “Uppsala” or “Theander” method, is a chemical method for determining total dietary fiber in foods. As in most of the other methods, free sugars, starch, protein and fat are removed from the sample. Soluble and insoluble fractions are separated. Instead of weighing dried residues, as in the gravimetric methods, the fractions are hydrolyzed with sulfuric acid and the individual neutral sugars are analyzed by high-performance liquid or gas chromatography. Pectin is measured colorimetrically and lignins are measured gravimetrically.

Table 1. AOAC - Approved Methods for the Analysis of Dietary Fiber			
Method No.	Method Title	First Action/ Final Action	Description
985.29	Total Dietary Fiber in Foods. Enzymatic-Gravimetric Method	1985/ 1986	Known as “Prosky” method. Approved for labeling.
991.42	Insoluble Dietary Fiber in Foods and Food Products. Enzymatic-Gravimetric Method (Phosphate Buffer)	1991/ 1994	Revised Prosky method for measuring insoluble fiber. Applicable for vegetables, fruit, and cereal grains. Approved for labeling.
993.19	Soluble Dietary Fiber in Food and Food Products. Enzymatic-Gravimetric Method (Phosphate Buffer)	1993	Revised Prosky method for measuring soluble fiber.
991.43	Total, Soluble and Insoluble Dietary Fiber in Foods. Enzymatic-Gravimetric Method (MES-Tris Buffer)	1991/ 1994	Improved Prosky method, buffer change improved precision. Applicable to processed foods, grain and cereal products, fruits and vegetables. Approved for labeling.
992.16	Total Dietary Fiber. Enzymatic-Gravimetric Method	1992	Known as “Mongeau” method. Applicable for cereals, beans, vegetables and fruits.
993.21	Total Dietary Fiber in Food and Food Products With $\leq 2\%$ Starch. Non-Enzymatic-Gravimetric Method	1993	Enzyme step removed for low starch foods, applicable to determination of $\geq 10\%$ total dietary fiber in foods with $\leq 2\%$ starch (dwb).
994.13	Total Dietary Fiber (Determined as neutral sugar residues, uronic acid residues, Klason lignin). Gas Chromatographic-Colorimetric-Gravimetric Method	1994	Known as “Uppsala” or “Theander” method, Very different from the other methods--a chemical method.

It is interesting to note that two of these last three methods have been approved by AOAC only for TDF analysis, even though the separation of soluble and insoluble portions is an integral

part of the methods. The total dietary fiber value for the Mongeau method (992.16) is actually determined as a sum of soluble and insoluble determinations. As mentioned earlier, the Uppsala method (994.13) separates soluble and insoluble fractions before generating values for the individual chemical components.

Several studies have addressed the differences in results using these methods. Asp and coworkers (8) have reported as much or more variability between laboratories for each method than variability between the methods (The Englyst method for non-starch polysaccharides was included in their study). Other studies show relatively linear correlations between methods, but these are usually food type dependent. For example, when comparing the enzymatic gravimetric (phosphate buffer) and the Mongeau methods, TDF values for fruits and vegetables are very similar. (9) However, TDF values for dried, cooked legumes are much higher using the phosphate buffer method because of the significant amount of resistant starch in these foods. (10) For fruits, the TDF values obtained using the Uppsala method are consistently lower than values obtained using the Enzymatic gravimetric (phosphate buffer) method. (11)

Dietary Fiber and other Carbohydrate Data in the National Nutrient Databank

A long range goal of the Nutrient Data Laboratory is to compile high quality data on individual carbohydrate components and to report carbohydrate by direct analysis. Immediate nutrient priorities are soluble and insoluble dietary fiber. Immediate food priorities are high consumption and high fiber foods on NDL's Key Foods list. (12) Key Foods are defined as those foods which, either by themselves or in mixtures, cumulatively contribute 80% of the intake of a key nutrient of public health significance to the US diet. When the foods in the 1995 Key Foods list were ranked by fiber content and total grams consumed, 72% of the dietary fiber consumed in this country came from only 100 foods.

In order to begin the process of compiling soluble and insoluble dietary fiber data and other priority nutrients such as starch and individual sugars, a three-part project was begun in 1993. Over 50 Key Foods were selected for analysis. Sampling plans were determined for each food based on 1988 sales (Nielsen Scantrack) data (13) and consultations with food specialists. Top name brands or varieties of foods were purchased from two major grocery chains and composited for each food. An overview of the sampling plan used for each food group is listed in Table 2.

In the first year of this project, the foods were purchased and prepared for analysis. They were analyzed for moisture, soluble and insoluble dietary fiber and individual sugars. In the second year, the foods were analyzed for individual sugars and total dietary fiber using different methods. They were also analyzed for starch content. These two phases of this project are now complete. Some of the carbohydrate data are discussed in detail in the poster, "Carbohydrate Data for Selected Foods in USDA's National Nutrient Database", (14) presented at this conference.

The third phase of this project will determine the rest of the proximate components (protein, ash and fat). The calculated carbohydrate by difference value will then be compared to carbohydrate determined directly using several methods.

Release 11 of Standard Reference

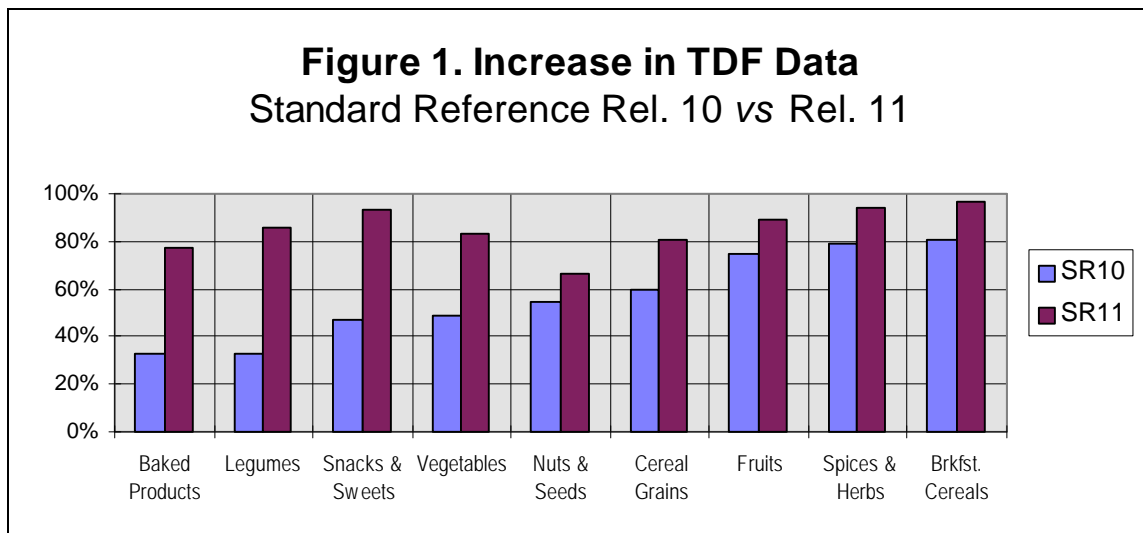
In September, 1996, the Nutrient Data Laboratory will be releasing Standard Reference Release 11, (15) which will be available from our bulletin board and via the Internet. An on-line search program will be offered which will allow unique data queries. The TDF values in Standard Reference, which have been updated and expanded in all of the food group categories, will be included. Soluble and insoluble fiber data will be available at a later date.

Table 2. Sampling Plan Summary		
Food Category	No. of Foods¹	General Sampling Plan (each food)
Baked Products	14	Top 1 or 2 name brands purchased from 2 major grocery chains and composited
Cereal Grains and Pasta ²	10	Top 2 or 3 brands (sometimes included a store brand) composited
Legumes, canned	8	
Fruits and Fruit Juices	19	Same variety (when possible) purchased from 2 major grocery chains and composited
Vegetables, raw and cooked	16	
Snacks and Sweets ²	7	Top 2 brands composited
Vegetables, frozen	2	

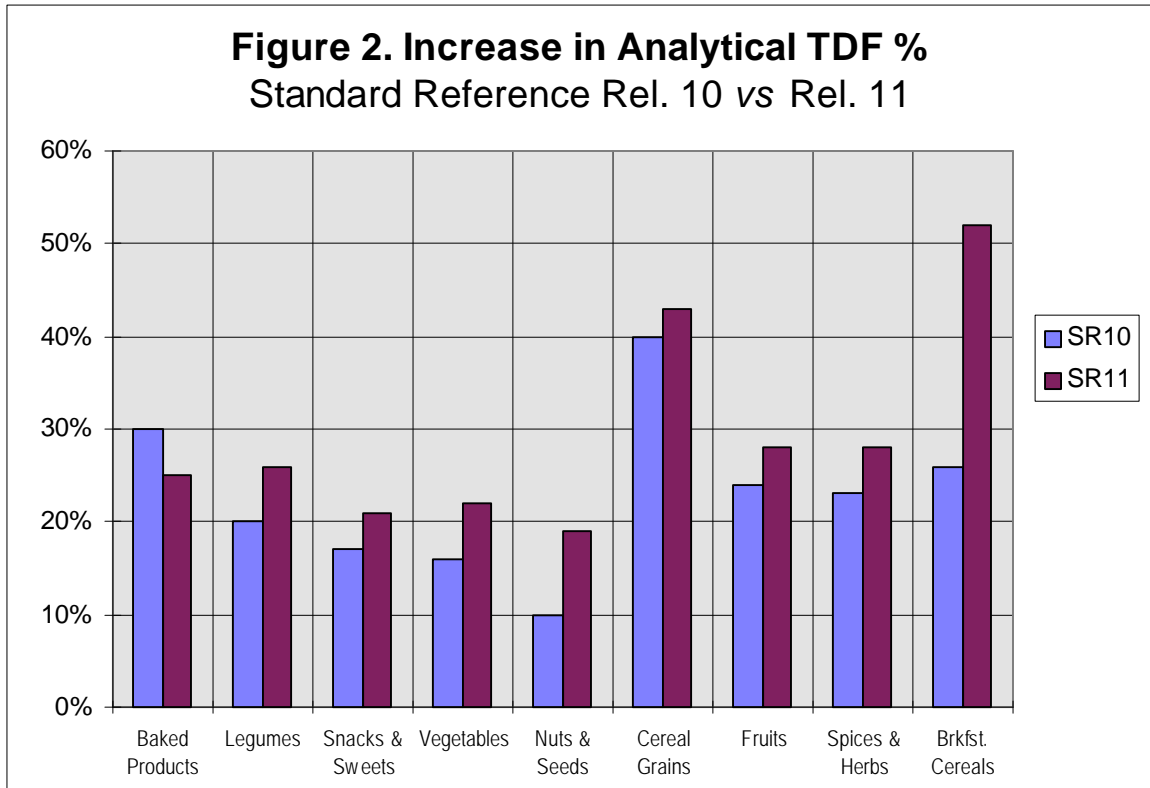
¹No. of foods = n.

²In a few cases, the top brand had such a high market share, that this brand was purchased from 2 major grocery chains and composited.

Figures 1 and 2 are graphical representations of the status of the TDF data in Standard Reference Release 11 as compared to Standard Reference Release 10. TDF values were first published in Standard Reference with Release 10 in July, 1993. In Figure 1, the percentages of foods with dietary fiber values are compared by food group. In Release 10, these values ranged from 34% in Baked Products to 80% in Breakfast Cereals. The percentage of TDF data in Release 11 will increase for all food groups, ranging from 68% in Nuts and Seeds to 97% in Breakfast Cereals.



In Figure 2, the percentage of analytical TDF values is compared. The percentage of analytical TDF values increased in all food groups except baked products, where some TDF values determined by recipe using newer formulations replaced analytical values with counts of 1 or 2. For the other food groups, the analytical percentages in Release 10 ranged from 10% in Nuts and Seeds to 44% in Cereal Grains and Pasta. In Release 11, the analytical percentages will increase from 20% in Nuts and Seeds to 53% in Breakfast Cereals.



Conclusion

The carbohydrate content of foods is an increasingly important area of food composition research. A number of new methods for determining dietary fiber in foods have been approved by AOAC in the last four years. The Nutrient Data Laboratory has begun to fund contracts for the gravimetric analysis of soluble and insoluble dietary fiber and the analysis of individual sugars and starch in Key Foods. This is the first step toward determining total carbohydrate directly by summing carbohydrate fractions instead of determining carbohydrate by difference in USDA food composition databases.

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