CFW PERSPECTIVE

Dietary Fiber Definitions at Risk

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Defining dietary fiber (DF) remains an interesting and controversial issue. At a minimum, an international DF definition is important for food labeling (e.g., claims) and the harmonization of global trade. In 1999–2000, AACC International organized national and international forums to debate and propose a definition for DF. In 2001, the U.S. Institute of Medicine proposed one (42). Although the IOM definition was reviewed by the U.S. Food and Drug Administration (FDA), the FDA is not in the process of accepting a definition. Consequently, there is no legal definition for DF in the United States. While the national debate to establish a new definition for DF continues, the current international debate to define DF presents some strong differences of opinion. The Codex Committee on Nutrition and Foods for Special Dietary Use on behalf of the Codex Alimentarius Commission, as far back as 1992, but especially in the past four years, received agreement among its delegates to advance a definition. "Dietary fibre means carbohydrate polymers with a degree of polymerisation (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerisation not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fibre consists of one or more of: 1) edible carbohydrate polymers naturally occurring in the food as consumed; 2) carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means, and 3) synthetic carbohydrate polymers." However, in July 2006, during a Food and Agricultural Organization–World Health Organization Scientific Update on Carbohydrates in Human Nutrition, a group of 11 carbohydrate experts (GROUP), two of whom were identified as DF experts, proposed that DF should be defined as consisting "of intrinsic plant cell wall polysaccharides" and that DF should only be associated with fruits, vegetables, and whole grains. Furthermore, the GROUP recommended the adoption of a method of analysis for nonstarch polysaccharides that would support their definition. They further recommended that the AOAC INTERNATIONAL methods should be discarded. This Perspective compares the strengths, limitations, and implications of these two internationally proposed definitions.

INTRODUCTION

The term "dietary fiber" (DF) is recognized by virtually everyone, but the question of what sources and forms of nondigestible carbohydrates can be included in the term DF is highly debatable. This controversy can be traced to the DF hypothesis. The DF hypothesis is simple, but emphatic and all encompassing: diets high in DF can prevent, and possibly treat, many of the metabolic diseases such as cancer, diabetes, heart disease, hypertension, and obesity. Furthermore, the hypothesis states that individuals consuming diets low in DF are more susceptible to these diseases (7,8,59,62,65).

Health-wise, a hypothesis that suggests disease prevention can be increased with the consumption of DF makes a powerful statement. It is, thus, understandable why there would be such interest in defining DF. Still, as well recognized as the term DF is, a consensus definition has not been easily accomplished. "Dietary fiber" is a complex mixture of different forms of nondigestible carbohydrates that have a variety of positive physiological properties when consumed. The nondigestibility of the dietary carbohydrates is the fundamental physiological difference between DF and the majority of digestible carbohydrates (i.e., starch and sugars) in the diet. These digestible carbohydrates generally provide 50% of the energy in the diet (44). It has been stated that the term DF should never have been used and should be abolished (6,23) and that DF can never be defined, specifically in terms of a single attribute. Five of the most common and relevant definitions of DF are listed in Table I, along with the interpretations of how the U.S. Food and Drug Administration (FDA) defines DF. While these definitions are important, these are not the topics of comparison for this article, which concerns the international debate between the Codex Alimentarius Commission (CODEX) and a proposal from the Food and Agricultural Organization–World Health Organization (FAO/WHO) Scientific Update on Carbohydrates in Human Nutrition, consisting of a group of 11 carbohydrate experts (GROUP), two of whom were identified as DF experts (FAO, 2007, personal commun.). The decision made by CODEX could affect and/or influence the United States and other countries in their deliberations to define DF.

Even though the definition of DF also has an impact on commerce, marketing, and international trade, and meaning for the consumer, from a scientific perspective, it is also important to have a DF definition. Indeed, defining DF has importance for 1) decisions about how new forms of nondigestible carbohydrates will be reported in the content area of the food label (e.g., food labeling); 2) recommendations for intake levels (e.g., Dietary Reference Intakes [DRI] in the United States); 3) decisions about the allowance of claims (e.g., content and health); 4) updates and utilization of nutrient content data bases; 5) dictates about the availability and/or need for methods of analysis; and 6) standardization among scientific studies as to the sources and forms of DF used and how they were measured. Also, methods of analysis continue to provide an interesting subset of the overall debate. Which should come first, the definition of DF or a method(s) to measure DF? Clearly, the definition should come first. You need to define what you are looking for before actively seeking it. A case in point, although the FDA does not have a legal definition for DF, the Nutrition Labeling and Education Act (NLEA) of 1991 specifies that for the purpose of nutrition labeling of food in the United States, DF includes the substances measured by AOAC Official Method 985.29 (32, Table I). In

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summary, a scientific definition of DF should be a simple statement that conveys a general description and sources. A standardized method or methods of analysis are necessary to confirm the quantity reported on a food label and are subsequently used to make any claim. No nutrients, particularly macronutrients, such as DF, total fat, available carbohydrate, or protein, which are by definition heterogeneous in their make-up, should be defined by their potential health-giving properties. Essential vitamins and minerals are defined as compounds required by higher animals for normal growth and maintenance and, thus, can help maintain health, but this definition does not necessarily mean they have potential health-giving properties.

The difference in opinions about what forms of nondigestible carbohydrate should be included and defined as DF is certainly at the root of the international controversy. History also adds to the value of the term: consideration is given to the traditional attitudes about DF fostered by the pioneers Dennis Burkitt, Hugh Trowell, Alex Walker, and Nigel Painter, who helped the nutrition and health communities rediscover the importance of this nutrient, originally called roughage (8,53,54,62,65). These later traditional beliefs appear to have rekindled and fueled the new international debate about what constitutes DF, how it should be defined, and how it should be measured. In fact, many of the traditionalists today prefer to abolish the term "dietary fiber" altogether (41). It has been stated that attempts to define DF are "doomed to failure" (40).

Before comparing the two proposed definitions for DF, it is worthwhile to summarize the events that led up to this controversy. CODEX has deliberated over this issue since 1992 (12), with that attention focusing on a definition during the past four years (13,16,18,19,20,21). At the 2006 Codex meeting, in sudden and unexpected actions, the FAO/WHO GROUP (and/or the WHO secretariat) ignored and/or dismissed the pending, near consensus CODEX definition of DF and proposed with some apparent notion of finality that their own individual, nonconsensus ideas should be received and accepted by CODEX (14,15).

THE CODEX DEFINITION OF DIETARY FIBER

History

Serious deliberations on the CODEX definition of DF started in 2002 during the 24th session of the Codex Committee on Nutrition and Food for Special Dietary Uses (CCNFSDU). During those deliberations, it was recognized that there was a need for a CODEX DF definition and that the definition was directly related to the international harmonization of claims (i.e., content and health) (17). Eleven countries, including the United States and five international nongovernmental trade organizations, were asked to draft a working definition for DF. Later, four more countries and two professional organizations, including the Institute of Food Technologists (IFT), expressed interest and were added to the working group. The "Proposal for a Definition and Methods of Analysis for Dietary Fibre" was presented at the 26th session of CX/NFSDU 04/3-Add.1 July 2004 (19).

Deliberations continued and "Guidelines for the Use of Nutrition Claims: Draft Table of Conditions for Nutrient Contents" (Part B Containing Provisions on Dietary Fibre) at Step 6, was presented at the 27th session of CCNFSDU, Agenda Item 3, CX/NFSDU 05/27/3 September 2005 (20). The U.S. delegate to CODEX received comments in preparation for each annual CODEX meeting and there was U.S. support for the CODEX definition. After the 27th CODEX session in 2005, one important provision for defining DF was met, but there was a lack of agreement on the methods to analyze DF and the Table of Condition regarding claims involving DF. The CODEX "Guidelines for the Use of Nutrition Claims—Dietary Fibre" and Appendix III pertaining to these decisions are available (15,16). The provision agreed upon by the CCNFSDU was the wording of the definition and properties of DF proposed at Step 7 (of 8 Steps of the CODEX procedure). The definition and properties of DF agreed upon, with changes to be put forward for ratification at the 28th session of CODEX (Oct. 30–Nov. 1, 2006), is presented below. As mentioned, this final CODEX definition was supported by the U.S. delegate to CODEX with recommended changes, who sought comments from U.S. interests. Because of the actions of the FAO/WHO GROUP, the CCNFSDU agreed to return the Draft Table of Conditions for Nutrient Contents containing provisions on DF to Step 6.

CODEX Definition and Properties of Dietary Fiber:

Definition:

Dietary fibre means carbohydrate polymers[1] with a degree of polymerisation (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerisation not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture.

Dietary fibre consists of one or more of:

- *Edible carbohydrate polymers naturally occurring in the food as consumed,*
- *carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means,*
- *synthetic carbohydrate polymers.*

Properties:

Dietary fibre generally has properties such as:

- *Decrease intestinal transit time and increase stools bulk*
- *Fermentable by colonic microflora*
- *Reduce blood total and/or LDL cholesterol levels*
- *Reduce post-prandial blood glucose and/or insulin levels.*

[1]When derived from a plant origin, dietary fibre may include fractions of lignin and/or other compounds when associated with polysaccharides in the plant cell walls and if these compounds are quantified by the AOAC gravimetric analytical method for dietary fibre analysis: Fractions of lignin and the other compounds (protein fractions, phenolic compounds, waxes, saponins, phytates, cutin, phytosterols, etc.) intimately "associated" with plant polysaccharides are often extracted with the polysaccharides in the AOAC 991.43 method. These substances are included in the definition of fibre insofar as they are actually associated with the poly- or oligosaccharidic fraction of fibre. However, when extracted or even re-introduced into a food containing non digestible polysaccharides, they cannot be defined as dietary fibre. When combined with polysaccharides, these associated substances may provide additional beneficial effects.

With the exception of non-digestible edible carbohydrate polymers naturally occurring in foods as consumed, where a declaration or claim is made with respect to dietary fibre, a physiological effect should be scientifically demonstrated by clinical studies and other studies as appropriate. The establishment of criteria to quantify physiological effects is left to national authorities.

Dietary Fiber Affects Physiological Properties

A common comment, if not always stated explicitly when

talking about defining DF, is that the definition must include a physiological function. What people are really trying to say is that the physiological functions that should be listed and promoted about DF are those associated with the DF hypothesis; prevention and/or treatment of heart disease, cancer, diabetes, and hypertension. However, the three most important physiological properties of DF, before disease prevention and treatment, is nondigestibility, partial and/or complete fermentation in the large intestine, and that these two physiological properties lead to laxation. It is only after these physiological functions are met and paths are found to significantly increase the level of DF in foods and diets that positive events associated with DF consumption, such as disease prevention and/or treatment, appear to be achieved. But and because of differences in chemical structures, different DF compounds and, perhaps more importantly, different mixtures of these compounds (as they always occur in cereals, fruits, vegetables, and legumes) are likely to have different degrees of physiological effects. It is thus very unlikely that a single or a short list of physiological and/or disease-related effects of DF can ever be established scientifically.

Table I. Common and Recognized Definitions for Dietary Fiber

Source	Definition
Trowell	"The skeletal remains of plant cells that are resistant to digestion (hydrolysis) by enzymes of man" (62). "Dietary fibre consists of the plant polysaccharides and lignin which are resistant to hydrolysis by digestive enzymes of man" (67). Also see Trowell (63,64,66).
FDA Measurement of dietry fiber (DF) in foods. The FDA has no definition for dietary fiber; a method(s) is specified to measure DF in foods and report these levels on the Nutrition Facts panel.	When the current FDA nutrition labeling regulations were proposed in November 1991, FDA specified that the DF content of a food would be determined by the method "Total dietary fiber in Foods, Enzymatic Gravimetric Method, First Action" in the *Journal of the Association of Official Analytical Chemists* (J. AOAC), 68:399, 1985, as amended in J. AOAC 69:370, 1986, and as modified in J., AOAC 71:1017, 1988." (56 *Fed Reg* 60366 at 60388; November 27, 1991). At the time the final rule was published (January 6, 1993), this method had been given final action status by the AOAC and was included in the most recent issue of AOAC Official Methods. The specification of the "Total dietary fiber in Foods, Enzymatic Gravimetric Method" was dropped in the final rule on the rationale that it was redundant to the compliance section of the regulation which specified: "composites shall be analyzed by appropriate methods as given in the "Official Methods of Analysis of the AOAC INTERNATIONAL," 15th ed., (1990)..." (21 CFR 101.9(g) (2)). The dietary fiber enzymatic/gravimetric method (AOAC 985.29) was in the 15th edition of AOAC Official Methods. The situation is unchanged from that in 1993; for the purposes of nutrition labeling of foods in the United States the AOAC Official Method "Total dietary fiber in Foods, Enzymatic Gravimetric Method," and its modifications, is the sole method for determining the dietary fiber content of food (35).
AACC International	"Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plants substances. Dietary fibers promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation" (1).
IOM	"*Dietary Fiber* consists of nondigestible carbohydrates and lignin that are intrinsic and intact in plants." *"Functional Fiber* consists of isolated, nondigestible carbohydrates that have beneficial physiological effects in humans" *"Total Fiber* is the sum of *Dietary Fiber* and *Functional Fiber*" (43,44).
CODEX	"Dietary fibre means carbohydrate polymers with a degree of polymerisation (DP) not lower than 3, which are neither digested nor absorbed in the small intestine. A degree of polymerisation not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fibre consists of one or more of: • Edible carbohydrate polymers naturally occurring in the food as consumed, • carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means, • synthetic carbohydrate polymers. Properties: Dietary fibre generally has properties such as: • Decrease intestinal transit time and increase stools bulk • Fermentable by colonic microflora • Reduce blood total and/or LDL cholesterol levels • Reduce post-prandial blood glucose and/or insulin levels" (16).
FAO/WHO EXPERTS	"Dietary fiber consists of intrinsic plant cell wall polysaccharides" (14).

AOAC INTERNATIONAL Methods of Analysis

As previously mentioned, methods of analysis are considered to play an important part on the process of defining DF. If any nondigestible carbohydrate is to be considered a source of DF, or added to a food, there must be a method of analysis. Historically, methods of analysis for food components have been validated through AOAC INTERNATIONAL (AOAC). The mission statement and recognition of AOAC and its methods, both nationally and internationally, can be found on the AOAC website (http://www.aoac.org). "It is the mission of AOAC INTERNATIONAL to serve the communities of analytical science by providing fit-for-purpose methods and services for assuring quality measurements." "AOAC INTERNATIONAL is a not-for-profit organization cited in the U.S. Code of Federal Regulations under Title 21: 'It is the policy of FDA in its enforcement program to use methods of analysis of AOAC INTERNATIONAL when available and applicable.' AOAC is also cited under Title 9 within this context by the U.S. Department of Agriculture. AOAC is internationally recognized by CODEX, ISO, and IUPAC as a provider of fully validated, reference methods and has been the leader in analytical methods validation for 120 years." It is important to mention that methods of analysis for DF have always been of interest to AACC International (AACC Intl.) members; they have been continuously involved with the development and certification through AOAC collaborative studies of almost every method for the measurement of nondigestible carbohydrates (3, Table II).

This request, from among CODEX members, for additional discussion on methods of analysis, (13) coincided with the DF06 International Symposium on Dietary Fibre held in Helsinki, Finland, June 12–14, 2006. It was decided by scientists planning to attend the symposium to hold a one-day workshop on methods for DF analysis. The purpose of the workshop was to review current methods of DF analysis, suggest improvements to these methods, and discuss new methods. The workshop was structured to offer a review of methods that would complement the pending CODEX definition and discussions within other countries. A complete summary of the workshop is in press (35). More information can be found at http://www.grainsandhealth.org/fiber/.

The review of the CODEX working definition of DF and the summary of the delegates' comments and recommendations for suggested changes (20,21) are similar to those received for the DF definition proposed by AACC Intl. (Table I). This comment should not be construed to mean or imply that the U.S. delegate to CODEX endorses the AACC Intl. definition for DF. The U.S. Institute of Medicine of the National Academy of Sciences (IOM) proposed a definition for DF (43), which was modified (44). While the IOM definition was reviewed by the FDA, the FDA is not in the process of accepting a definition. There is no legal definition for DF in the United States. A definition of DF was sought by the IOM in establishing new Dietary Reference Intakes (DRI) for DF (44). The similarity in ideas, concepts, and dialogue that occurred over the years while CODEX drafted their definition of DF is amazingly parallel to the AACC Intl. definition, which concluded over two years (1). While the definitions for DF proposed by the IOM differ from those definitions proposed by AACC Intl. and CODEX (Table I), all three organizations deliberated through open discussions with total transparency. This cannot be stated for the GROUP's actions.

The CODEX "Step 6" definition is inclusive of all forms of food-safe nondigestible carbohydrate having a degree of polymerization ≥3. The complete CODEX definition lists one or more physiological functions dealing with health (Table I). This separation of chemical identity from the physiologically related health properties of DF is advantageous for a number of reasons. By establishing the separate chemical identities for nondigestible carbohydrates, no immediate recognition and/or bias is placed on what physiological functions DF must possess. However, this first part of the CODEX definition contains the universal physiological phrase nondigestible in all its deliberations, which is excluded in the GROUP's definition. The state of being nondigestible separates DF from all other carbohydrates (i.e., starch and sugars). And because DF is nondigestible, it confers its many attributes associated with a normal intestinal function (i.e., bulking, water binding, viscosity, and increased bacterial mass) and might, when consumed in greater amounts, help achieve the states of wellness associated with the DF hypothesis. The CODEX definition, by giving a clear identity to the sources and ranges of molecular sizes that encompass the term DF, can avail itself of the AOAC methods that are available or those that can be developed to measure these components in foods. And finally, the clear separation of chemical identity from disease-associated and/or physiological properties could allow for direct or implied health claims, if proven (69). These properties are clearly dose-dependent and would preclude allowing indiscriminate health claims on labels. One gram of fiber probably has no measurable effect. The burden of proving that DF can prevent and/or treat any disorder should be the total responsibility of the person or entity making the claim (69).

Similar to defining DF, acceptance of analytical methods has not been an easy process. While a method should not define DF, methods are needed to measure that which is defined as DF. A case in point is the FDA definition of DF (Table I). The GROUP proposed the same reasoning, what can be recovered by their method (nonstarch polysaccharides [NSPs]) should be used to define DF as "intrinsic plant cell wall polysaccharides." Methods of development and acceptance have gone through much debate and advancement. Measurements for crude fiber yielded to the analysis of acid detergent fiber (ADF) and neutral detergent fiber (NDF) values; values for nondigestible carbohydrates without the use of enzymes (56). While ADF and NDF have applicability in animal nutrition, they are not con-sidered useful in human nutrition. However, measurement of DF in foods without soluble components (i.e., wheat bran) can be achieved with a NDF method (See AOAC Method 992.16, Table II). The approach, using enzymes to remove the starch and protein, and the proper selection of these enzymes, went through extensive review and evaluation over the years (10). Through these efforts, there has been an accumulation of many acceptable methods to measure nondigestible carbohydrates in foods—the most notable and generally used methods for the measurement of DF in foods being the AOAC methods (35, http://www.grainsandhealth.org/fiber).

As discussed in greater length in the summary document of the DF06 workshop on methods for DF measurement, when it was mandated to label DF in the United States, the primary AOAC Intl.-approved method to measure DF was Method 985.28. At the time that this method was developed and approved, the significance and recovery of resistant starch and nondigestible oligosaccharides were not realized. It must be remembered that it was only during this time period that AOAC Intl. Method 985.28 was certified (1988) that the existence, recovery, and importance of soluble DF had been recognized; the recovery of soluble DF was predicated on its precipitation in alcohol. One important aspect of the DF methods workshop (35, http://www.grainsandhealth.org/fiber) was to discuss existing AOAC methods and their complementary ability to measure most forms of nondigestible carbohydrates in or added to foods. In summary, and for example, to measure the total dietary fiber (TDF) in a food sample such as whole wheat bread, with naturally occurring or added resistant starch and inulin-type fructans (fructo-oligosaccharide [FOS]), would require at least the use of AOAC

Table II. AOAC INTERNATIONAL Methods for the Analysis of Dietary Fiber

AOAC Method and Title Collaborative Study Reference	Comments
985.29 Total Dietary Fiber in Foods; J. AOAC 68,677 (1985) and (69) (1986)	Sample digested at 95–100°C to gelatinize starch and heat stable amylase, then digested with protease and finally amyloglucosidase. Alcohol is added to filtrate to precipitate soluble dietary fiber (SDF), which is filtered with insoluble dietary fiber (IDF) residue. Total residue is called total dietary fiber (TDF). Ash and protein are measured in residue and these values are subtracted from residue weight to get corrected TDF value. Use of a phosphate buffer in this method has lead to co-precipitation of the phosphates with older enzymes systems giving potentially variable dietary fiber values.
991.42 Insoluble Dietary Fiber in Foods and Food Products—Enzymatic-Gravimetric Method, Phosphate Buffer; J. AOAC Intl. 75,360 (1992)	Method was originally developed and tested to determine total dietary fiber (TDF) as the sum of insoluble dietary fiber (IDF), and soluble dietary fiber (SDF) fractions. However, because of unacceptable variability in measuring the SDF fraction (See AOAC Method 993.19), the method was only given AOAC approval to measure IDF.
991.43 Total, Soluble, and Insoluble Dietary Fiber in Foods—Enzymatic-Gravimetric Method MES-TRIS Buffer; J. AOAC Int. 75, 395 ((1992)	Method for the measurement of TDF, either by direct measurement or as the sum of IDF and SDF. This is the most commonly used method worldwide for the measurement of TDF in foods since the mid 1990s. This method uses organic buffers (MES-TRIS) in place of phosphate buffers used in previous methods. This method essentially replaces methods 985.29, 991.42, and 993.19.
992.16 Total Dietary Fiber—Enzymatic-Gravimetric Method; J. AOAC Int. 76,423 (1993)	Method for the measurement of TDF, but two independent samples and methods are used to measure IDF and SDF fractions; IDF and SDF values are added to give TDF, and there is some indication of overstating total dietary fiber due to isolation of certain components in both fractions simultaneously since two separate sample aliquots are used. For samples with low or no SDF content, measurement of IDF as neutral detergent fiber (NDF) is quick and inexpensive. Suitable for measuring TDF in fecal samples.
992.28 (1→3)(1→4)-Beta-D-Glucans in Oat and Barley Fractions and Ready-To-Eat Cereals Enzymatic-Spectrophotometric Method; J. AOAC Int. 76,1069 (1993)	Mill sample and desugar ready-to-eat cereal and digest sample with lichenase to degrade beta-glucans to beta-oligosaccharides. Digestate is treated with beta-glucosidase to yield glucose, which is then measured spectrophotometrically after treatment with glucose oxidase-peroxidase.
993.19 Soluble Dietary Fiber in Foods and Food Products—Enzymatic-Gravimetric Method (Phosphate Buffer); J. AOAC Int. 77, 690 (1994)	Method for the determination of SDF. With the failure of an earlier collaborative study (See AOAC Method 991.42), because of inadequate precision in recovery of SDF, the protocol was modified. The reevaluation of the SDF fractions in a second collaborative study resulted in the AOAC acceptance of this protocol. The method is still used, but has generally been replaced by AOAC Method 991.43.
993.21 Total Dietary Fiber in Foods and Food Products with ≤2% Starch; J. AOAC Int. 77,687 (1994)	Method is for the determination of dietary fiber with less than 2% starch. A simplified dietary fiber method that is a convenient and inexpensive for samples containing little starch.
994.13 Total Dietary Fiber Determined on Neutral Sugar Residues, Urionic Acid Residues, and Klason Lignin; J. AOAC Int. 78,1030 (1995)	Method for TDF; residue isolated after enzyme(s) treatment is further hydrolyzed in sulfuric acid and individual sugars are measured by gas chromatography or high performance liquid chromatography. More expensive and time consuming compared to other methods, specifically 991.43. Method requires a highly trained/skilled technician.
995.16 beta-D-Glucan in Oats Streamlined Enzyme Method; J. AOAC Int. 80,580 (1997)	Beta-D-Glucan is specifically hydrolyzed by lichenase to oligosaccharides, which are then quantitatively cleaved to glucose by beta-glucosidase. Measure glucose with glucose oxidase-peroxidase.
997.08 Fructans in Food Products Ion Exchange Chromatographic Method; J. AOAC Int. 80,1029 (1997)	Fructans are extracted from sample with boiling water. Three sugar analyses of water extract are accomplished using high performance anion exchange chromatography with pulsed amperometric detection on: 1) aliquot after water extraction; 2) after water extract is treated with amyloglucosidase to remove starch; and 3) final digestion with inulinase. Glucose and mainly fructose from fructans are used to determine fructans levels in sample.
999.03 Measurement of Fructan in Food Enzymatic/ Spectrophotometric Method; J. AOAC Int. 83,356 (2000)	Fructan in sample is extracted in hot water. Initial enzyme digestion degrades sucrose and starch, which are reduced to sugar alcohols. Remaining fructan is hydrolyzed with fructanase and sugars (glucose and mainly fructose) measured spectrophotometrically after treatment with p-hydroxybenozic acid hydrazide.
2000.11 Polydextrose in Food Ion Chromatography; J. AOAC Int. 84,472 (2001)	Polydextrose is extracted in water and filtrate remaining after centrifugation is passed through an ultrafilter and treated with isoamylase, amyloglucosidase, and fructanase. High pressure anion exchange chromatography with electrochemical detection is used to measure polydextrose.

2001.02 trans-galactooligosaccharides (TGOS) in selected Food Products Ion Exchange Chromatography; J. AOAC Int. 85,417 (2002)	Extract both TGOS and lactose with hot phosphate buffer, save aliquot. Hydrolyze TGOS and lactose with beta-galactosidase. Initial and hydrolyzed sample are analyzed with high-performance anion-exchange chromatography with pulsed amperometric detection. Measure galactose and lactose in initial and hydrolyzed samples. Calculate TGOS based on net concentrations of galactose and lactose.
2001.03 Dietary Fiber Containing Supplemented Resistant Maltodextrin High MW RMD by Method 985.29 and Low MW by HPLC Enzymatic-Gravimetric Method and Liquid Chromatographic Determination; J. AOAC Int. 83,1013 (2000) and 85,435 (2002)	AOAC Method 985.29 is initially used to recover/measure residue consisting of IDF, SDF, and resistant maltodextrin (RMD) fraction also precipitated in ethanol. Remaining filtrate containing low molecular weight (LMW) RMD is desalted and concentrated filtrate. The LMWRMD is quantitated by liquid chromatography. Dietary fiber is sum of IDF, SDF, and LMWRMD.
2002.02 Resistant Starch in Starch and Plant Material Enzymatic Digestion; J. AOAC Int. 85,1103 (2002)	Digestible starch is removed from sample by heating for 16 hrs at 37°C in presence of pancreatic α-amylase and amyloglucosidase. Stop reaction with ethanol, centrifuge, and dissolve pellet in 2M KOH. Hydrolyze solubilized resistant starch with amyloglucosidase and measure glucose with glucose oxidase-peroxidase. Applicable only to plant materials and RS2 and RS3 types of resistant starches.
2006.08 Determination of Methylcellulose and Hydroxypropyl Methylcellulose Food Gums in Foods and Food Products: A Collaborative Study. Submitted to J. AOAC Int. July 2006. (In press) First Action Approval Pending	Samples are analyzed as described in AOAC 991.43. Digestate solutions are refrigerated to ensure full hydration of MC or HPMC, and then are filtered and analyzed by size exclusion liquid chromatography.

This table can be found online at http://www.svs.fi/DFW06/ as part of the proceedings of the DF06 International Symposium on Dietary Fibre held in Helsinki, Finland, June 12–14, 2006.

Methods 991.43, 997.08, and 2002.02 (3, Table II, http://www.grainsandhealth.org/fiber). It is acknowledged that no method or combined use of methods for the analysis of DF miss or duplicate the measurement of any DF component, respectively.

The FAO/WHO GROUP and Their Definition

The definition for DF proposed by the GROUP is presented below (14,16).

> *The experts agreed that the definition of dietary fibre should be more clearly linked to fruits, vegetables and wholegrain cereals. To achieve this aim, the definition should include the following:*
>
> *1. A source element identifying that dietary fibre is an intrinsic component of these food groups.*
>
> *2. A chemical element identifying the component to be measured.*
>
> *Based on the rationale described below the following definition is proposed: "Dietary fibre consists of intrinsic plant cell wall polysaccharides."*

The FAO/WHO periodically seeks expert consultation on issues of human nutrition. Two recent consultations (with public notice) were the Joint FAO/WHO Consultation on Carbohydrates (28) and the Joint WHO/FAO Expert Consultation on Diet Nutrition and the Prevention of Chronic Diseases (72). At the 27th session of CODEX (13), delegates were informed that an FAO/WHO consultation would be undertaken to provide a scientific update of the more urgent carbohydrate-related topics. From the FAO's perspective, the urgent issue was related to sugar (e.g., 29,30,31). From the WHO's perspective, the urgent issues related to those contained in the Global Strategy on Diet, Physical Activity, and Health (71) and sugar was the carbohydrate discussed explicitly. There was no urgent issue, nor any published directive, that dealt with DF (although fruits, vegetables, and whole grains were mentioned; 29,30,31). Eleven experts of the FAO/WHO Scientific Update on Carbohydrates consultation panel met in Geneva on July 17–18, 2006, to submit and discuss drafts of scientific papers prepared in advance. Although the definition for DF was not a specific charge of the panel, the focus of their work appears to have been devoted to DF and not sugar, if the GROUP's summary comments are an indication (20,21). There does not appear to have been any justification for the GROUP's review of DF, nor have the scientific papers discussed at the 2006 Geneva meeting been published. Communication with FAO/WHO indicates these reviews should be available in 2007 (FAO, 2007, personal commun.). Although the final reviews to be prepared by the GROUP are not available, sufficient information is available through the FAO/WHO, CODEX, and the CCNFSDU to present rebuttals to many, if not all, of the ideas and recommendations presented by the GROUP.

There was a lack of transparency in public disclosures in the appointment of the experts in the GROUP and the real purpose for their existence. This information, the identity of the 11 member FAO/WHO Scientific Update on Carbohydrates consultation panel was only made available by the WHO after CODEX issuance of CL 2007/3-NFSDU January 2007 (16) (FAO, 2007, personal commun.). While 40 experts are indicated as being involved with the scientific papers to be prepared and published as part of the joint FAO/WHO Scientific Update on Carbohydrates in Human Nutrition, only 11 experts were directly involved in preparing the five main chapters or review papers for the scientific update. While CODEX knew of the existence of the FAO/WHO expert panel, the GROUP's definition for DF and how it was presented at the 2006 CODEX meeting was a complete surprise (15). The ideas and opinions expressed by the GROUP are not new. The same ideas, definition, justification, and method for NSP go back to 1987, almost 20 years (26). To further underline the outdatedness of the GROUP's opinions, their ideas and definition for DF were proposed in 1994 to the European Commission for inclusion in the EU Food Labelling Directive. The EU Scientific Committee for Food never agreed on this proposal. A summary of these procedures is available (55). One country, New Zealand, still champions the use of the methods to measure NSPs in foods, but they are considering the use of AOAC methods (35, http://www.grainsandhealth.org/fiber). The GROUP restates the original thinking presented by

Denis Burkitt, Hugh Trowell, Alex Walker, and Nigel Painter, based on their work in Africa more than 30 years ago (8,53,54,62,65). While the GROUP states that more recent epidemiological studies support their definition, they dismiss totally, and actually avoid reference to, the voluminous amount of nutrition and clinical research on those sources of nondigestible carbohydrates they wish to exclude from their definition.

Because of the importance and need to define DF, public discussions are warranted. The GROUP's ideas must be debated and resolved. However, in retrospect, the ideas presented by the GROUP and the manner in which they disrupted the activities of CODEX in their work to define DF, should have never been allowed to happen.

FAO/WHO GROUP's Justification for Defining Dietary Fiber

In presenting and discussing the GROUP's definition, it must be stated again that their definition is predicated on a method of analysis that claims to measure NSPs. The GROUP offered many justifications for their definition of DF and their method of analysis for NSP. Several of these points are extracted below for comment (14). These include:

> *1. The established epidemiological support for the health benefits of dietary fibre is based on diets that contain fruits, vegetables and wholegrain cereal foods, which have the characteristic of containing plant cell walls and; dietary fibre is defined as a natural food component and no further criteria are required.*

The primary justification of the GROUP's definition of DF is a combination of the original ideas of the DF hypothesis with more recent epidemiological studies that show increased consumption of fruits, vegetables, and whole grains are associated with health benefits (49,50). The health benefits of the increased consumption of fruits, vegetables, and whole grains are not questioned. However, these epidemiological studies cannot specifically pick out NSP measured by a specific method or TDF measured by either AOAC Methods 985.29 or 991.43 as the active components. As previously mentioned, the FAO/WHO (29,30,31) and possibly every health professional and health organization, such as the World Health Assembly (71), European Union (22), and the U.S. Department of Agriculture Dietary Guidelines (68), recommend that people eat more fruits, vegetables, and whole grains. The GROUP is trying to do this under the guise that only the consumption of the unique combination of nondigestible carbohydrates, called NSP, and only those found in plant cell walls will help achieve health when consumed. Such a hypothesis simply ignores decades of scientific research that clearly demon-strates that cereals, fruits, and vegetables contain many more health-promoting compounds. Indeed, some of the evidence is to the contrary. A meta-analysis of prospective studies showed that NSP consumption actually had no significant relationship to the risk of the serious disease colon-rectal cancer (9). Among the more recently reported epidemiological studies, and the few mentioned by the GROUP, there has been no evidence that DF is protective against colon cancer. Two long term clinical studies did not show a reduction in cancers with increased consumption of DF (2,57). There is no scientific evidence or justification to exclude DF from sources other than fruits, vegetables, and whole grains as beneficial. Will our knowledge, as implied by the GROUP, have to be reevaluated that β-glucan is not useful in lowering serum lipids? Where would the recommendations of the GROUP leave soluble DF, which is not found in cell walls?

While fruits, vegetables, and whole grains contain plant cell wall components, this does not indicate that plant cell walls are the "active" components as postulated by the GROUP. In fact, one of the 11 experts was among a group of authors that report it is the magnesium in these food groups that can lower serum insulin levels in middle-aged women (33). This same expert, as part of another study, reports that women from the Nurses Health Study following a low carbohydrate diet, and presumably low DF, had lower risk of heart disease (38).

While the GROUP can be applauded for their efforts to find a way to heighten the importance of fruits, vegetables, and whole grains, their abuse of, and omission of, scientific data is suspect at least, but mainly inaccurate. Although the GROUP continually extols their unproven method for NSP, they fail to mention the existence of AOAC Method 994.13, "Total Dietary Fiber Determined on Neutral Sugar Residues, Uronic Acid Residues, and Klason Lignin" (Table II). This AOAC-approved method could be used to provide the information deemed necessary by the GROUP.

Equally disturbing is the fact the GROUP discounts the high number of nutritional and clinical studies showing the benefits of DF added to foods. This Perspective is not intended to offer a review of the scientific data supporting these claims. A few suggested references are Cho and Dreher (11), Gray (37), Institute of Food Science and Technology (42), Kritchevsky and Bonfield (48), McCleary and Prosky (51), and van der Kamp (70). The GROUP further contends that it is specifically the plant cell walls of fruits, vegetables, and whole grains that are the efficacious components. While there might be evidence of increased consumption of fruits, vegetables, and whole grains and improved health observed in reported epidemiological studies, the same correlation cannot be specifically associated with the DF or NSP provided by these foods. The actual amount of DF consumed among subjects participating in these epidemiological studies is not actually known; the level of NSP and/or TDF consumed by these individuals is estimated from nutrient data bases. And almost all nutrient data bases report the levels of TDF in foods by AOAC methods. The GROUP is confusing the data obtained by the epidemiology studies they report, which supports food-based dietary guidelines (eat more fruits, vegetables, and whole grains) but not nutrient-based guidelines (eat more DF) and requirements (consume X g of DF daily). Although seemingly difficult to separate, fruits, vegetables, and whole grains are not DF, and conversely, DF is not fruits, vegetables, and whole grains. Epidemiological studies support dietary guidelines (68) and nutritional and clinical studies support nutrient-based guidelines (i.e., eat more DF; eat less saturated fat, cholesterol, and sodium). Together, the advice to eat more fruits, vegetables, and whole grains and eat more DF is good. However, for both these foods and the nutrient DF, people are not following good advice.

It is more than understood that DF can be a complex mixture of nondigestible carbohydrates that reach the large intestine. We might not know all the forms and sizes of DF ingested in a mixed diet. And we certainly do not know all the physiological aspects that can be attributed to DF consumption; we have not even tried to understand the interactions among ingested DF and different physiological functions. We do know that it is not prudent to eat one source of DF in large amounts and/or that concentrated forms of DF should not be consumed without adequate amounts of water. And finally, we know that DF intakes are woefully lacking in the diet, and the necessary steps to increase intakes to meet the new recommended intakes of 30–38 g/day in the United States (44) and 32–45 g/day in the Netherlands (39) can hopefully be achieved through the consumption of all foods containing DF. We do not

know the upper safe limits of DF intake, but from estimated consumption among African populations and modern day vegetarians, intakes that range between 50 and 100 g per day would appear to be safe. While some early research suggested that DF might interfere with mineral bioavailability, this is no longer considered a problem (36). High DF intakes, as obtained from higher consumption of fruits, vegetables, and whole grains, can help to reduce energy (calories or kilojoules) in the diet. Other sources of DF added to foods, which the GROUP excluded from their definition, can complement those supplied by plant foods. Currently, it is estimated the average DF consumption in the United States and in most countries throughout the world ranges between 18–20 g/day; nearly one-half current recommended intakes. The GROUP makes no mention of legumes, which are a rich source of DF and resistant starch. It would be interesting to speculate what would be the reported DF intake of individuals if all forms and sources of nondigestible carbohydrates added to foods were removed from food labels and food composition tables.

While there are good correlations in some epidemiological studies showing an association of increased DF consumption and lower incidence of disease, these studies are also showing a lower energy intake among these individuals and overall lower body weight and/or weight management. The GROUP fails to mention the fact that individuals who consume a varied and moderate diet, exercise, and avoid smoking have healthier and longer lives (46,47). Although epidemiological studies look for and, hopefully, find correlations, it is difficult to pinpoint the one or more food components that are the mechanistic explanation for the observation. While epidemiological studies help establish a hypothesis, they also set the stage to conduct clinical studies to test and possibly confirm the hypothesis. Another limitation of the DF hypothesis is that it is too general, too encompassing to suggest one food component responsible for the prevention and/or possible treatment of the most common diseases contributing to early (or premature) death.

> *2. The structural polysaccharides are the major part of plant cell walls, and by determining this characteristic component it is possible to indicate the presence of other beneficial substances, such as micronutrients and phytochemicals that are present in the plant. This approach is preferable to the determination of all the individual parts of plant cell wall material, which is both impractical and would not add to the nutritional message that is provided by focusing on the polysaccharides of the plant cell wall. Therefore, lignin and other substances are not included in the definition.*

In cursory reading of the GROUP's ideas it is not totally evident why the GROUP concerned themselves only with the structural polysaccharides that constitute plant cell walls. The only logical explanation is that a specific method is needed to complement their definition. As will be discussed, the GROUP's definition of DF is tied to their method of analysis.

The GROUP implies that by using their method to measure cell wall components they can also "indicate the presence of other beneficial substances, such as micronutrients and phytochemicals." Measuring the DF in any food sample with any method is time consuming and requires due diligence by the analyst. Compounding any current assay for DF by searching and measuring for other compounds does not seem to be an efficient and prudent use of laboratory time and resources. There are approved AOAC methods for the measurements of many, not all, food components (3).

There is agreement with the GROUP that lignin should not be part of a definition for DF and that they should include the term in a footnote as suggested by CODEX. Many people, especially analysts, feel that inclusion of the term lignin reflects the measurement of plant-based foods. Because many AOAC methods for TDF recovery measure lignin, the term is included in definitions that are based on AOAC measurements. The method proposed by the GROUP does not measure lignin, so the term is eliminated from their definition. However, as the GROUP can be criticized for wording their definition for DF to accommodate their method, other definitions appear to be written to accommodate methods (Table I).

> *3. Other carbohydrates share the feature of resisting digestion in the small intestine, but these do not provide a consistent indicator of plant rich diets, and they can be affected by food processing or may be added to food.*

The GROUP brings up an interesting point that deserves much more discussion than can be provided here. It must be acknowledged that there are other food components that can go undigested and pass into the large intestine. This is an active topic of research in Japan where the term luminacoid is used to characterize all nondigestible food components passing to the large intestine (45). An example of major nondigestible food components, other than nondigestible carbohydrates, is fractions of plant proteins. This could possibly be another reason to recommend the consumption of fruits, vegetables, and whole grains. Although additional research might be needed to obtain a better understanding of the importance of all the nondigestible compounds passing to the large intestine, the focus is on nondigestible carbohydrates, be they called NSP or TDF. Yet, it can be continually debated that there is a difference between plant cell wall polysaccharides and all other forms of nondigestible carbohydrate obtained from whole plant foods, isolated from plants, and/or modified and/or synthesized. There is no efficient and reliable analytical method to distinguish NSPs in foods that are obtained from plant foods (plant cell walls) or those added to foods. Whatever methods are used, the values obtained represent one or a combination of nondigestible carbohydrates. As these methods cannot differentiate the original sources of DF (nondigestible carbohydrate) upon consumption, it is felt that the intestinal tract does not differentiate and/or recognize them as being of plant origin or added to foods.

Eating a mixed diet of unprocessed and processed foods provides a mixture of DF passing through the body exerting a collective array of positive physiological functions. At best, in defining DF, a collective term is used to indicate a collective distribution of nondigestible carbohydrates resulting in a collective array of physiological functions, mainly and initially intestinal, when consumed.

As will be expanded upon, there is no method for DF analysis that can be used as a "consistent indicator of plant rich diets." Any method for the measurement of DF is developed and evaluated to provide reproducible results within and among laboratories. The AOAC collaborative study program is rigorous and consists of First Action approval for reproducibility within and among laboratories, and after an approximate two-year discussion period, Final Action approval is granted by the AOAC. A total of 15 methods have AOAC Final Action for the measurement of dietary fiber in foods or added to foods (3,35).

While these methods can measure most forms of nondigestible carbohydrates, they are not used to define dietary fiber. These AOAC methods are recognized worldwide.

4. Instead, resistant starch, oligosaccharides and fibre supplements should be researched and, if shown to be beneficial to health, be promoted in their own right.

The DF hypothesis has been stated. What were the levels and types of DF consumed among the African populations observed by Denis Burkitt, Hugh Trowell, Alex Walker, and Nigel Painter in developing the DF hypothesis? The levels, and equally important the types, of DF consumption among these African populations is not known. This issue has been discussed (4,5). Of the limited data available, these African populations were consuming almost all cereal and vegetable foods with modest fruit intake. Based on estimated food intakes and using DF values measured in these foods much later and reported in food-nutrient data bases, the DF intakes were corrected and now estimated to range from 60–90 g/day; a significant amount compared to intake now reported for populations around the world. It is also known that the diets among these African populations contained mainly starch from foods that would contain resistant starch. Recent evaluation of published data from others (52,58) and by Topping and colleagues (60,61) suggest that in addition to the DF in these African diets, the amount of resistant starch was significant and should be included and recognized when discussing the original DF hypothesis. The GROUP dismisses resistant starch, but refer to its importance elsewhere (9), and the smaller nondigestible inulin-type fructans, although the latter class of compounds is almost ubiquitous in plant foods. The GROUP fails to recognize the physiological importance of these and other nondigestible carbohydrates, not because they select to just omit their importance, but because these compounds are not recovered in the assay they want to promote in support of their definition.

5a. It does not include non digestible oligosaccharides, which have a DP mostly between 3 and 9, because the experts participating in the authors' meeting thought that this group of carbohydrates, which can be called short chain carbohydrates, have chemical, physical and physiological properties that are distinct from the polysaccharides of the plant cell wall, e.g. water solubility, organoleptic properties, effects on the gut microflora (prebiotic), immune function and calcium absorption making them a unique group of carbohydrates, which should be measured separately. They have not, hitherto, been considered to be part of dietary fibre.

It is acknowledged that there are smaller forms of nondigestible carbohydrates in foods and diets and they probably contribute to different physiological properties.

When the DF hypothesis was developed, while the consumption of plant foods was recognized, there was limited or no knowledge of resistant starch or nondigestible oligosaccharides (called short chain carbohydrates by the GROUP). Many nondigestible oligosaccharides in addition to oligofructans (34) might also be considered prebiotics, potential sources of energy for intestinal bacteria.

The GROUP allows themselves to be distracted with the claims made about these newer sources of DF. The identity, through measurement, of all nondigestible carbohydrate is the essence and foundation of a DF definition. Health claims of any type must be substantiated through scientific study and guidance standards to achieve significant scientific agreement (69). The definition of DF should not be burdened with claims or inference to the DF hypothesis, which still remains to be proven. Everyone would like to see the DF hypothesis proven. Putting aside the claims made for nondigestible oligosaccharides and resistant starch, it is difficult to imagine that the GROUP failed to acknowledge the three important physiological benefits of these compounds: 1) nondigestibility; 2) a source of energy for intestinal bacteria; and 3) that these two physiological properties contribute to laxation. The fact that nondigestible oligosaccharides and resistant starch are "nondigestible" causes them to contribute to laxation, granted not to the same degree as wheat bran, but the fact they are fermented clearly indicates they are recognized by the body as DF, a nutrient, and no claims need be made.

5b. Non-digestibility cannot be measured in the laboratory. Therefore, there is no method that can support such a definition.

This is perhaps the most ill-conceived and false statement by the GROUP. As mentioned, the nondigestibility of carbohydrates separates DF from all other macronutrient-carbohydrates. To say that "non-digestibility cannot be measured in the laboratory" is incorrect. Through years of study, in humans and many animal species, all forms of DF have been shown to resist intestinal hydrolysis; they are nondigestible carbohydrates. This statement by the GROUP can only be explained by their wish to exclude this term from their definition for DF. The method they propose to extract and measure NSPs (24,25) in plant foods uses the enzymes amylase, pullulanase, and pancreatin to obtain the nondigestible! A more complete list of the method(s) proposed by the GROUP is available (27). The suggestion to remove the term "non-digestibility" from their definitions is totally contradictory based on the method of analysis they propose to use to measure NSPs, which uses en-zymes to obtain a nondigestible residue.

5c. Dietary fibre defined as "intrinsic plant cell wall polysaccharides" includes the phrase "intrinsic" as does the definition of the US National Academy of Sciences. This emphasizes that dietary fibre reflects fruits, vegetables and wholegrain cereal foods.

It is acknowledged that plant foods contain intrinsic forms of nondigestible carbohydrates. A suggestion is offered to the GROUP and others interested in promoting and using the term intrinsic. Allow for the free and unencumbered, not regulated, use of the term intrinsic when marketing fruits, vegetables, and whole grains, such as "A source of intrinsic dietary fiber." No definition is needed, nor any method of analysis.

FAO/WHO Method for Measurement of NSPs

6. Regarding the Methods of analysis are a secondary issue, and their suitability should be assessed by how well they measure the defined food component. Defining dietary fibre as "intrinsic plant cell wall polysaccharides" provides the analyst with a clear objective and the method or choice of methods should be those that most accurately and reproducibly identify and measure these polysaccharides.

7. As part of the scientific update on the issues related to measuring dietary fibre, the NSP and AOAC gravimetric approaches were compared, as summarized in Appendix 2. This comparison clearly identifies the strengths and limitations of the two main approaches to the measurement of dietary fibre.

The idea presented by the GROUP—that methods of analysis for DF are secondary to defining DF—contradicts their definition of DF, which is based on their method for NSP. They go to great length to discount the utility and practicality of AOAC methods while embellishing their method; the GROUP provides five extensive tables promoting the benefits of their method while criticizing AOAC Intl. methods (14,16).

The AACC Intl. Dietary Fiber Committee and its members have been productive since 1986 in developing and helping to organize and participate in both AACC Intl. and AOAC sponsored collaborative studies. These AOAC collaborative studies are designed to demonstrate the reproducibility of a method within a laboratory and among at least eight laboratories. Both AACC Intl. and AOAC members did participate in collaborative studies to evaluate the methods proposed by the GROUP for NSPs over an approximate 10-year period starting in 1988. Because of a continued lack of reproducibility within and among the laboratories participating in these studies, the assays(s) could never be certified by AOAC. There is no explanation why these assays for NSP suggested by the GROUP have not been proposed for AOAC collaborative study and verification.

Again, AOAC Intl. Method 994.13, "Total Dietary Fiber Determined on Neutral Sugar Residues, Urionic Acid Residues, and Klason Lignin," (Table II) could accomplish the needs of the GROUP.

While it is apparent why the GROUP wants to associate their method with their definition, the information provided by their method and the most commonly used AOAC methods 985.28 and 991.43 are not that different. The GROUP suggests major differences between the two methods (14,16), but much of this information is filler.

Using the method for NSPs as suggested by the GROUP, the results will not identify the DF as coming from fruits, vegetables, or whole grains. Yes, the NSP method can identify the individual sugars and their respective amounts, but having these data serve as a fingerprint for fruits, vegetables, and whole grains is highly improbable. Since the analysis of individual sugars requires gas-liquid chromatography (GLC) or high-performance liquid chromatography (HPLC), the time, equipment needs, and cost of their assay would be significantly higher compared to most AOAC Intl. methods, thus contrary to the GROUP's claims. AOAC Method 994.13 can measure sugars.

A further conundrum presented by the GROUP is their statement that "Non-digestibility cannot be measured in the laboratory." To obtain the free sugars, the nonstarch method they propose first liberates a nondigestible residue, which also contains lignin, by using the enzymes amylase, pullanase, and pancreatin. How or why the GROUP removes the word non-digestible from their definition for DF cannot be explained or justified. Acid hydrolysis of the residue removes the lignin before the sugars are analyzed. This is not to be considered a disadvantage, but the method for NSPs will give values that range from 15–25% lower compared to those obtained using AOAC Intl. methods.

In summary, the GROUP suggests that their method, which is still to be verified for reproducibility within and among laboratories, is best because it can support their proposed definition for DF: "Dietary fibre consists of intrinsic plant cell wall polysaccharides."

SUMMARY

Science can be simply defined as knowledge; others might think of science as research to obtain knowledge. While it can be said we do not have all the knowledge about DF and how it should be defined, research has given new knowledge, some of which remains to be substantiated. However, three fundamental aspects of DF have been confirmed repeatedly. DF is principally a carbohydrate food component that is not digested in the human small intestine, thus, passing to the large intestine. In the large intestine, almost every form of DF is fermented to some degree. For example, cellulose may be 30–60% fermented and inulin is fully fermented. In passing through to the large intestine, DF fulfills its essential nutrient capacity; it provides energy for bacterial growth and maintenance. Considering the broad and complex range of nondigestible carbohydrates that are ingested with foods, intrinsic in plant foods, isolated and/or synthesized, and added to foods, and that may range in size greater than 100,000 saccharide units down to three, collectively they give DF its unique physiological property that is manifested along the entire intestinal tract. It is often stated that any definition of DF must include its physiological function. These are the quintessential physiological properties of dietary fiber. These physiological properties—nondigestibility, fermentability, and laxation—are the function, functionality, and essentiality of DF.

There may be many hypotheses associated with DF; the DF hypothesis for health (7,8,59,62,65), the resistant starch hypothesis (60,61); the prebiotic hypothesis (34), etc. These hypotheses must be proven. What has been proven is that the body recognizes food-safe nondigestible carbohydrates as being nondigestible and potentially fermentable in the large intestine, and collectively these properties of DF contribute to laxation.

CODEX has long and openly debated a proposed international definition for DF. It is complete in identifying the range of nondigestible carbohydrate food ingredients also recognized by

The international and national debate on defining dietary fiber (DF) might continue for a long time. However, the debate and process for the Codex Alimentarius Commission (CODEX) definition of DF can only be communicated through member nation's delegates to CODEX. While CODEX asked for comments with a March 31 deadline (ftp://ftp.fao.org/codex/Circular_letters/CXCL2007/cl07_03e.pdf), a final ratification of the pending CODEX definition will occur at the November 2007 CODEX meeting. Comments on this CODEX issue can be communicated to our delegate to CODEX and the Institute of Food Technologists: U.S. Delegate to the CCNFSDU, Office of Nutritional Products, Labeling and Dietary Supplements, Center for Food Safety; Applied Nutrition, Food and Drug Administration, 5100 Paint Branch Parkway (HFS-800), College Park, MD 20740 (CCNFSDU@fda.hhs.gov) and; Institute of Food Technologists, Attn: Rosie Newsome (rlnewsome@ift.org), 525 West Van Buren, Suite 1000, Chicago, IL 60607.

A panel discussion of this issue, "FAO/WHO Experts Decide to Redefine Dietary Fiber as Intrinsic Plant Cell Wall Polysaccharides," will be held at the IFT meeting in Chicago, Monday July 30, 2007, 8:30–10:00 a.m.

Discussion on the CODEX definition for DF, and the Institute of Medicine and AACC International definitions for DF are planned for the October 7–10, 2007, AACC International meeting in San Antonio, Texas.

the body as nondigestible. The CODEX definition identifies but separates the health promoting properties of DF. Yes, there might be some minor further changes to improve the wording of the CODEX definition. The CODEX definition should move forward and would serve well the goals and objective of CODEX and all countries, including the United States, in harmonization of world trade and consumer protection.

The GROUP's definition for DF is basically a restatement of the DF hypothesis and focuses on nondigestible carbohydrates, but the GROUP's definition is mainly an attempt to make an association with the phrase "intrinsic plant cell wall polysaccharides" solely to promote the consumption of fruits, vegetables, and whole grains. And the GROUP chooses their method for NSPs over AOAC Intl.–approved methods for nondigestible carbohydrates and DF.

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