Dietary Fiber Guidelines in the Exchange Lists for Menu Planning

Should they be revised?

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Early innovative research by Anderson (1) and Jenkins (2) led to a wide array of observations (3,4) that have established dietary fiber as a beneficial component of the dietary treatment for diabetes mellitus. Higher fiber food items in the *Exchange Lists for Meal Planning* (5) are identified with a symbol to assist individuals in increasing total dietary fiber intake. Even though the most recent nutrition principles for diabetes management do not specify higher fiber intakes, the committee recognized that individuals with diabetes, like the general public, need to increase fiber intake (6). Maintenance of the symbol indicating higher fiber foods in the exchange lists would be a beneficial reminder of this need, which also promotes foods that are usually less calorically dense.

We recently completed fiber analysis of over 300 foods using a detailed chemical method (Uppsala method) (7,8). About two-thirds of the same samples were also analyzed using a gravimetric procedure that was developed to determine fiber values for food labeling; the Association of Official Analytical Chemists (AOAC) method (9). During a preliminary comparison, we observed that many of the fiber suggestions in the exchange lists were higher than what was obtained by either the Uppsala or AOAC method.

This article will first briefly review major methods of fiber analyses, highlighting differences that may be responsible for differences in fiber values. We will then compare fiber values obtained by the methods of Anderson (10) and Southgate (11), which were used for the recommendations in the exchange lists, with our two sets of analyses and with data obtained using the Englyst method that is a major source for the fiber data in the most recent edition of the British Food Composition Tables (12). These comparisons will be used to illustrate how different analytical steps produce different fiber values.

METHODS OF FIBER ANALYSIS — Dietary fiber is usually defined as lignin plus the polysaccharides that cannot be digested by endogenous enzymes in the gastrointestinal tract of monogastric species (13–15). Several polysaccharides are involved: cellulose, which is a polymer of glucose units; hemicelluloses and gums, which contain primarily neutral sugars such as xylose, arabinose, mannose, galactose, glucose, and occasionally rhamnose and fucose (although hemicelluloses also may contain uronic acids); and pectins, which are primarily polymers of galacturonic acid, but with small amounts of neutral sugars (14,15).

Most methods of dietary fiber analysis can be divided into two approaches: enzymatic-gravimetric and enzymatic-chemical analysis (13–15). In a gravimetric procedure, enzymatic and chemical steps are used to extract nonfiber components. The weight of the remaining residue, after correction for incompletely removed materials, is dietary fiber. In a chemical analysis of fiber, enzymatic and chemical steps also remove nonfiber materials. However, the fiber components are individually measured, and the sum of neutral and acidic sugar constituents of the polysaccharides, which are quantitated by high-performance liquid chromatography (HPLC), gas chromatography (GC), or colorimetrically, and Klason lignin is the measure of dietary fiber.

The different approaches to fiber analysis are incorporated into Fig. 1. Most methods do not use all of the steps. Major methods of fiber analysis for human foods have been extensively reviewed (14,15), and nearly all have modifications to obtain soluble and insoluble fractions. Many methods use the insolubility of most polysaccharides in ~80% ethanol to recover the fiber. In all methods, fat is extracted from a dry food sample if it is present at about >5% (by weight).

Two enzymatic-gravimetric procedures are being used for human food analysis: the AOAC method (9) and the procedure developed by Mongeau and Brassard (16) in Canada. In the AOAC

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AOAC, Association of Official Analytical Chemists; HPLC, high-performance liquid chromatography; GC, gas chromatography.

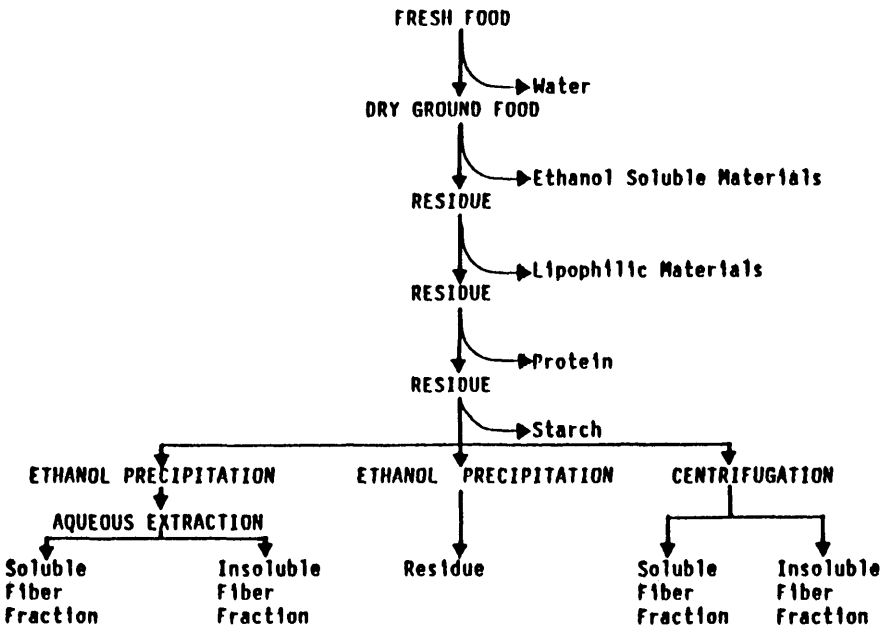

Figure 1—*Measuring dietary fiber in human foodstuffs. Reprinted with permission from Marlett et al. (14).*

method, a dried sample is subjected to short enzymatic steps to remove starch and solubilize protein. The residue that is obtained by making the mixture ~80% ethanol (Fig. 1, middle) is weighed and analyzed for crude protein content ($N \times 6.25$) and ash. Because neither protein nor ash are considered to be fiber, they are subtracted from the residue weight to obtain a total dietary fiber value. The Mongeau and Brassard method measures total dietary fiber as the sum of the gravimetric yield of soluble and insoluble fiber fractions, corrected for ash content, that are determined in two separate analyses. Soluble fiber is the ethanol precipitate from an aqueous extract, obtained by autoclaving, that has been treated to extract starch and solubilize protein. The insoluble fiber is measured by the neutral detergent fiber method developed by Van Soest (17,18) to which enzymatic steps have been added to remove starch. Both methods have evolved through a series of modifications since they were first published (19,20).

Two approaches are emerging as major enzymatic-chemical procedures for fiber analysis: the Englyst method (21), which is a modification of the Southgate procedure (22); and the Theander method (7,8), which has been recently coined the Uppsala method (23). Both methods have undergone several modifications: those for the Uppsala procedure aimed at simplifying the analysis, and those for the Englyst method aimed to simplify and address several analytical issues.

The modification of the Uppsala method, which we used to analyze the fiber in the 300 foods, includes steps to extract water, ethanol-soluble simple sugars, lipophilic materials, and starch (Fig. 1) (24,25). The soluble and insoluble fiber fractions are separated by centrifugation, and the soluble fraction is recovered by dialysis and lyophilization; not by precipitation with ethanol (Fig. 1, right). Aliquots of soluble and insoluble fractions are acid hydrolyzed for analysis of uronic acids colorimetrically as an estimate of pectins and neutral sugars by HPLC. Klason lignin is measured as the material insoluble in 72% sulfuric acid.

The Englyst procedure does not contain an initial ethanol step (21). Complete starch extraction is assured by solubilization in DMSO before enzymatic digestion. Fiber polysaccharides are obtained by precipitation with ethanol. Fiber-derived neutral sugars are measured by GC or colorimetry, and uronic acids are measured by colorimetry. Lignin is not measured.

The Southgate and Anderson procedures also are both enzymatic-chemical methods. The pioneering method of Southgate (22) has been essentially replaced by the Englyst versions. The method used by Anderson (10) is a modification that includes features from both the Southgate and Englyst methods. The Southgate procedure used for the fiber data, on which the exchange lists guidelines are based, included initial extractive steps to remove simple sugars and lipids (22). Starch was removed by enzymatic hydrolysis, and fiber polysaccharides were recovered by ethanol precipitation. Following acid hydrolysis, neutral sugars and uronic acids were measured colorimetrically. The method used by Anderson did not contain initial steps to extract sugars and lipids (10). Starch was removed by enzymatic hydrolysis with or without pretreatment with DMSO. Fiber polysaccharides were recovered by ethanol precipitation and analyzed as in the Englyst method.

These seemingly minute details explain why fiber values obtained using different methods may not be similar (14). The fiber content of a food will be underestimated if a fiber component is lost during analysis. For example, some fiber polysaccharides do not precipitate in ethanol (15,26) and, thus, would not be recovered as either gravimetrically or chemically determined fiber (Fig. 1, last steps). Alternately, enzymes used to extract starch are sometimes contaminated with enzymes that will degrade fiber constituents (15). Undetected fiber components also lead to low fiber values. For example, Englyst does not include lignin as part of dietary fiber (21). If polysaccharides are not hydrolyzed completely into

single sugar units, they will not be detected by GC (14,15) and, thus, not measured as part of the fiber.

The major reason for inflated dietary fiber values is the recovery of nonfiber components as fiber. These most commonly are ash, protein, starch, and endogenous simple sugars or those added during food processing (14,15). Unextracted starch and simple sugars will be measured by both gravimetric and chemical methods of fiber analysis. Most enzymes used to hydrolyze starch in fiber methods are not those used in the gastrointestinal tract, and with few exceptions, most of this starch and simple sugars is digested in the gastrointestinal tract. The relationship between starch that is not extracted during fiber analysis and starch bioavailability in vivo cannot be defined with any certainty (14,15). None of the analytical procedures mimic the dynamic process of digestion in the gastrointestinal tract, although Asp et al. (27) recognized the role of gastric acidity and pepsin in his analytical approach. Until more is known about the relationship between analytical and in vivo measures of starch digestibility, the generally accepted approach is to measure and subtract starch not removed by the usually short, nonphysiological steps used in fiber methods.

SOURCES OF FIBER DATA FOR COMPARISON

— Data obtained by five methods of dietary fiber analysis were compared (Tables 1–4). The Southgate data were originally published in the 4th revised edition of the British Food Composition Tables (11) and were republished in the 5th revised and extended edition (12); this edition also was the source of the Englyst fiber data. Anderson fiber data have been published in the literature (10). The fourth and fifth sources of fiber data for comparison were the two methods we used to analyze the same food samples for fiber: the Uppsala method and the AOAC procedure (25,28–32). Foods were analyzed by the AOAC method because this procedure is widely used to obtain fiber data for food labeling. Both sets of data were obtained by methods previously described (24,25).

For the Uppsala method, aliquots of the soluble and insoluble fractions were also analyzed for starch and protein contents to determine recoveries of the fractions, because if recoveries were not adequate, it was likely that some fiber component was not analyzed. Recoveries of the insoluble fiber fractions were typically >90%; of the soluble fractions, 70–75% (25, 28–32). The lower recovery of the soluble fraction is probably due to the use of an inaccurate nitrogen-to-protein ratio and the failure to account for the ash. The detailed fiber composition of the foods has been published (25,28–32).

Foods were selected from the exchange lists for comparison of fiber values if they had been analyzed by the Uppsala method. The serving size for one exchange of each food item was obtained from the food exchange lists (5). The gram weight for the drained, edible portion of the household measure for one exchange was obtained from published sources (33–35) or product labels. The total dietary fiber content per exchange was calculated for each food using the fiber values (% fresh weight) and the gram weight for the drained, edible portion of one exchange. Typical portion sizes and weights for higher fiber foods not on the exchange lists (parsnip, pumpkin) were obtained from published sources (33–35).

COMPARISON OF DIETARY FIBER DATA

— Twelve of the 15 foods listed as containing ≥3 g of fiber per exchange in the starch/bread list were analyzed by the Uppsala method (Table 1). Only 3 of the 12 foods contained ≥3 g of fiber per exchange when they were analyzed by the Uppsala method. All except one (corn) of the nine AOAC fiber values were greater than the corresponding Uppsala data. Southgate fiber data were available for six foods: all except one value (bran cereal, flaked) was greater than those determined by the Uppsala method. The Englyst fiber contents of the two bran-containing foods were lower and that for peas higher than those obtained by any of the other methods. The rest of the Englyst data and all except the lentil fiber value in Anderson data were generally comparable to or lower than the Uppsala fiber values.

Six of the seven fresh and three of the four dried fruits listed as containing ≥3 g of fiber per exchange in the fruit list were analyzed by the Uppsala method (Table 2). Five of the nine fruits contained ≥3 g of Uppsala fiber per exchange; three contained ≤1.8 g per exchange. Southgate fiber data for fruits were usually substantially greater than either the Uppsala or AOAC fiber values. Englyst values for fiber in fruits were less, in several instances substantially so, than those obtained by the Uppsala method (Table 2).

We analyzed 24 of the 28 vegetables that were listed as containing 2–3 g of fiber by the Uppsala method and 21 by the AOAC method (Table 3). If both the raw and cooked forms are considered, only four foods (artichoke, green beans, broccoli, and brussels sprouts) had about 3 g per exchange of Uppsala fiber. Nearly two-thirds of the vegetable exchanges (18 of 30) contained <2 g per exchange and 8 contained ≤1.5 g per exchange of Uppsala dietary fiber (Table 3). We included in our comparison two vegetables (artichoke and brussels sprouts) that were not highlighted as higher fiber foods (≥3 g) but which contained >3 g per exchange of Uppsala fiber. The majority (72%) of the AOAC vegetable fiber values were within 0.3 g of the Uppsala values (Table 3). Several of the 19 Southgate and 22 Englyst fiber values also were similar to the Uppsala data, but there were foods for which the three methods gave substantially different results. All except 3 of the 10 Anderson fiber values were similar to (≤0.4 g difference) the Uppsala fiber data.

Table 1—*Foods in the starch/bread list identified as containing ≥3 g of total dietary fiber per exchange*

	One exchange		Total dietary fiber (g/serving fresh weight)				
	Household	Weight (g)	Uppsala	AOAC	Southgate	Englyst	Anderson
Bran cereal, concentrated	1/3 C	28	8.1	9.7	8.4	6.9	8.6
Bran cereal, flaked	1/2 C	19	3.7	—	3.3	2.5	2.9
Wheat germ	3 Tbsp.	18	2.5	—	—	2.8	—
Beans and peas, cooked	1/3 C	58	2.6*	3.2*	—	—	2.7†
Lentils, cooked	1/3 C	66	2.0	2.7	—	2.5	3.5
Beans, baked	1/4 C	63	2.8	—	4.3	2.3	2.6
Corn	1/2 C	83	1.6	1.5	3.2	1.2	1.5
Corn on cob	1 ear (6" long)	151	1.9	2.5	3.8	2.0	—
Lima beans, canned	1/2 C	88	2.6	3.7	—	—	3.1
Peas, green, canned or frozen	1/2 C	81	2.8	3.3	5.6	3.9	3.1
Squash, winter, acorn or butternut	1 C	204	3.8	4.9	—	—	2.1
Whole wheat crackers, fat added (Triscuit)	4–6 crackers	28	2.6	3.1	—	—	—

Weight refers to drained, edible portion. Bran cereal, concentrated is wheat bran; fiber would be less if oat bran was considered. * Mean of cooked or canned Northern, navy, black, and lima beans, and black eye and crowder peas; † mean of cooked or canned white, navy, and lima beans, and black-eyed peas.

Two vegetables, raw Chinese cabbage (1 C, 76 g) and raw zucchini (1 C, 130 g), contained ≥3 g of fiber in the free foods exchange list, but contained 0.9 and 1.2 g, respectively, of Uppsala fiber. Two higher fiber foods were not on the lists, parsnip and pumpkin; one exchange of cooked parsnip (½ C, 78 g) contained 3.0 g and canned pumpkin (½ C, 122 g) contained 3.6 g of Uppsala fiber.

The average fiber content of one exchange of fruits is stated in the menu planning list as 2 g. We analyzed 33 of the 41 fruits on the list using the Uppsala method and 24 using the AOAC procedure (Tables 2 and 4). The average Uppsala fiber content of one exchange of fruit not highlighted to contain ≥3 g per exchange of fiber was 1.5 ± 0.9 g and ranged from 0.4 g per exchange in mandarin oranges and canned pineapple to 3.6 g per exchange for dates (Table 4). Over half of the fruits in Table 4 contained <1.5 g per exchange of Uppsala fiber. If the higher fiber fruits listed in Table 2 are included, the average Uppsala fiber content of one exchange of all fruits was 2.0 ± 1.5 g. Two fruits, fresh unpeeled pear and dates, that were not highlighted as high fiber foods (≥3 g) contained >3 g per exchange of Uppsala fiber. AOAC fiber in fruits was usually either similar to or slightly greater than the Uppsala data (Table 4). There were no consistent differences between the Uppsala and the Southgate or Englyst fiber values for fruits. The Anderson fiber values for fruits were not substantially different than the Uppsala data.

Table 2—*Fruits identified as containing ≥3 g of total dietary fiber per exchange*

	One exchange		Total dietary fiber (g/serving fresh weight)			
	Household	Weight (g)	Uppsala	AOAC	Southgate	Englyst
Fresh						
Blackberries	3/4 C	114	7.4	8.0	7.5	3.5
Blueberries	3/4 C	110	3.2	3.9	—	—
Nectarines	1 fruit (2 1/2" diam.)	136	1.6	1.9	3.0	1.6
Raspberries	1 C	124	5.2	5.5	8.3	3.1
Strawberries	1 1/4 C	188	3.2	3.6	3.8	2.1
Tangerines	2 fruits	201	3.6	—	3.4	2.6
Dried						
Apricots	7 halves	25	1.7	1.9	—	—
Figs	1 1/2 fruits	31	2.5	2.7	3.5	2.1
Prunes	3 medium fruits	25	1.8	2.0	3.2	1.4

No data for Anderson method of analysis. Weight refers to drained, edible portion.

Table 3—*Vegetables identified as containing 2–3 g of total dietary fiber per exchange*

	One exchange		Total dietary fiber (g/serving fresh weight)				
	Household	Weight (g)	Uppsala	AOAC	Southgate	Englyst	Anderson
Artichoke	1/2 medium	60	3.2	3.7	—	—	—
Asparagus	1/2 C	106	1.9	2.3	0.8	0.8	2.5
Beans, green or wax	1 C	110	2.8	2.8	3.3	2.4	—
	1/2 C	65	1.5	1.5	—	2.7	1.9
Bean sprouts	1 C	104	1.4	1.6	(5.8)*	1.6	—
	1/2 C	62	0.9	1.0	—	—	—
Beets	1/2 C	85	1.8	2.1	2.0	1.6	2.1
Broccoli	1 C	88	2.9	2.4	—	2.3	—
	1/2 C	78	1.9	2.6	—	1.8	2.2
Brussels sprouts	1/2 C	78	3.2	3.4	—	3.4	3.5
Cabbage	1/2 C	73	1.7	1.7	(1.7)*	1.3	1.5
Carrot	1 C	110	2.5	—	2.9	2.6	3.5
	1/2 C	76	2.0	2.3	2.1	1.7	—
Cauliflower	1 C	100	2.3	2.2	1.9	1.8	—
	1/2 C	62	1.3	—	1.0	1.0	1.6
Eggplant	1/2 C	48	1.2	1.3	1.4	1.1	—
Greens, collard, mustard, or turnip	1/2 C	81	2.4	—	2.8†	2.1†	—
Kohlrabi	1/2 C	82	1.6	1.7	—	—	—
Mushrooms	1/2 C	78	2.0	—	1.8	0.9	—
Okra	1/2 C	92	2.1	2.6	3.8	3.3	—
Onion	1 C	160	2.2	2.5	2.4	2.2	—
	1/2 C	105	1.6	1.8	0.7	0.7	—
Pea pods	1/2 C	80	1.7	1.8	—	—	—
Peppers, green	1 C	100	1.7	—	(1.9)*	1.6	—
Rutabaga	1/2 C	85	1.9	2.2	1.0	0.6	—
Sauerkraut	1/2 C	73	1.9	2.3	—	—	—
Spinach	1/2 C	90	2.1	2.6	2.8	1.9	2.0
Tomato	1 large, raw	123	1.0	1.1	1.6	1.2	1.0
Water chestnuts	1/2 C	70	0.8	1.0	—	—	—
Zucchini	1/2 C	90	0.7	0.8	—	—	—

Artichoke and brussels sprouts are not highlighted in exchange lists to contain ≥3 g fiber. 1/2 C serving is canned or cooked; 1 C serving is raw. Weight refers to drained, edible portion. * Estimated value; † spring greens.

CONCLUSIONS— In this comparison, fiber values obtained using the Uppsala method were the standard against which other data were compared. This decision was based on several features of the Uppsala method that minimize the possibility of obtaining an erroneous fiber value. This method was carefully developed with attention to several possible sources of analytical error (7,8,14,15,36). The determination of the recoveries for the soluble and insoluble fiber fractions that was part of the original method (36) we used minimized the possibility that fiber components were not being measured. The possibility that fiber values were inflated by starch was minimized by measuring starch not extracted during fiber analysis and subtracting it from the fiber values. This starch was not included in the Uppsala fiber value because it is not always the same as resistant starch or starch not digested in vivo in humans. The use of an initial 80% ethanol extraction of simple sugars that may co-precipitate with fiber polysaccharides in 80% ethanol (14,15,37,38) eliminated this source of inflated fiber values. Finally, the original Uppsala procedure (36) used dialysis and lyophilization to recover the soluble fiber fraction instead of precipitation with ethanol; this eliminated the possibility that highly branched polysaccharides, which do not precipitate completely in ethanol, would be lost (26).

Our comparisons of fiber values obtained by five different methods of analysis indicate that many of the fiber guidelines in the exchange lists are higher than the data generated by the majority of the methods. It is unlikely that the consistently higher fiber values used to prepare the exchange lists are a result of the analyses of different food samples. However, varietal differences may explain

Table 4—*Dietary fiber in one exchange of fruits*

	One exchange		Total dietary fiber (g/serving fresh weight)				
	Household	Weight (g)	Uppsala	AOAC	Southgate	Englyst	Anderson
Fresh, frozen, and unsweetened canned fruit							
Apple, fresh unpeeled	1 fruit (2" across)	92	2.1	2.2	(1.8)*	1.7	1.8
Applesauce, unsweetened	1/2 C	122	1.5	1.7	2.2	1.5	2.0
Apricots, fresh, unpeeled	4 medium fruits	141	2.1	2.3	2.7	2.4	—
Apricots, canned, unpeeled	4 halves	75	1.4	1.6	0.9	0.7	—
Banana (9" long)	1/2 fruit	59	1.0	—	1.8	0.6	1.2
Cantaloupe (5" across)	1/3 fruit, cubed	177	1.2	—	1.6	1.8	—
Cherries, canned	1/2 C	89	0.8	—	(0.6)*	0.5	—
Fruit cocktail, canned	1/2 C	84	0.9	1.1	0.8	0.8	—
Grapefruit with membrane	1/2 medium fruit	98	1.3	1.3	(1.6)*	1.3	1.2
Grapefruit, segments, with membrane	3/4 C	131	1.8	1.8	(2.1)*	1.7	1.6
Grapes, fresh	15 small fruits	75	0.7	0.8	0.6	0.5	—
Mandarin oranges	3/4 C	161	0.4	0.5	(0.5)*	0.5	—
Honeydew melon, fresh	1/8 medium fruit, cubed	187	1.1	1.4	1.5	1.1	—
Orange (2 1/2" across)	1 fruit	125	1.9	2.2	2.3	2.1	1.7
Peach, fresh, unpeeled (2 3/4" across)	1 fruit	158	2.7	2.9	3.6	2.4	—
Peach, canned	2 halves	102	1.4	1.5	0.9	0.8	1.6
Pear, fresh, unpeeled	1/2 large or 1 small	121	3.4	—	—	2.7	—
Pear, canned	2 halves	102	1.7	—	(1.5)*	1.4	3.0
Pineapple, fresh	3/4 C, diced	117	1.2	1.6	1.5	1.4	—
Pineapple, canned	1/3 C, diced	52	0.4	—	0.4	0.3	0.9
Plum, Friar, fresh, unpeeled (2" across)	2 fruits	124	1.5	—	2.9	2.0	—
Watermelon	1 1/4 C, cubed	200	0.8	—	0.6	0.2	—
Dried fruit							
Dates	2 1/2 medium fruits	21	3.6	2.0	1.4	0.7	—
Raisins	2 Tbsp.	19	0.8	0.8	1.2	0.4	—

Pear (fresh) and Dates are not highlighted in exchange list to contain ≥3 g fiber. Weight refers to drained, edible portion. For Apple, Uppsala and AOAC values are means of the analyses of Granny Smith, Macintosh, and red delicious apples; Southgate and Englyst data are averages of several varieties. For Grapes, Uppsala and AOAC values are means of the analyses of black, red, and Thompson green grapes; Southgate and Englyst data are averages of several varieties. For Orange, Uppsala and AOAC values are means of the analyses of navel, Temple, and Valencia oranges; Southgate and Englyst data are averages of several varieties; Anderson data is of the analysis of navel oranges. * Estimated value.

some of the discrepancies between the U.S. (Anderson and our data) and British (Southgate and Englyst) data. But, in the U.S., the food supply is relatively consistent in terms of cultivar and maturity; control of these variables are two ways in which a marketable food supply is consistently provided that can be stored and transported over long distances. Commercial canning or freezing or cooking in the home usually has a negligible effect on total fiber, although such processing may increase the proportion of fiber that is extracted into the soluble fraction (39–41). Baking or commercial processing of cereal and grain products has a variable effect. In some instances, total dietary fiber in baked products may be increased by the detection of heat-modified molecules as *artifact* lignin or by the inclusion of some starch that is rendered unavailable to analytical extraction by processing (14,18).

In contrast, it is well established that different methods of analysis may produce different fiber values even when the same food sample is used (15,28–32,42). The bases for the differences are largely analytical and do not relate to the ability of one method to estimate a more physiologically meaningful fiber value than another method.

The most likely cause for the higher fiber values obtained by the Southgate method for foods in the starch/bread list is the measurement of incompletely hydrolyzed starch as dietary fiber (14,15,37,38,43). Our experience indicates that for legumes and some grain products, the higher fiber values obtained by the AOAC method, compared with the Uppsala procedure, are due to the short-

ness of the starch hydrolysis steps, which are not sufficient to adequately remove starch (29,30,32). The differences between the Uppsala and Anderson data for squash and lentils could be due to the analysis of different samples or to starch.

If large amounts of simple sugars not derived from fiber remain in the solution, as would be the case during fiber analysis of fruits or processed grain products, a portion may co-precipitate with the fiber polysaccharides during this ethanol step (37,38). Previous research indicates that simple sugars trapped in the fiber ethanol precipitate may be responsible for the elevation of some of the AOAC values compared with Uppsala data (37). This is most likely the basis for the small but consistent and statistically significant higher AOAC fiber values for fruits when the same samples are analyzed by the Uppsala and AOAC methods (31). Because the original Southgate procedure extracted any existing simple sugars from a food at the beginning of an analysis, it is more likely that the use of a colorimetric assay in the original Southgate procedure to quantitate fiber-derived neutral sugars is responsible for the overestimation of fiber-derived sugars present (43).

There are generally fewer differences among the fiber data for the nonstarch vegetables. Analysis of different samples or co-precipitation of nonfiber sugars could be the basis for some of the differences. Because we used the same samples to obtain the Uppsala and AOAC data, the latter reason seems to be a more likely cause of higher fiber values. Although the difference between the two data sets for vegetables is small, it was statistically significant (28).

In contrast to the generally larger fiber values obtained by the other methods, compared with the Uppsala data, some of the Englyst data (e.g., bran and some fruits) were substantially lower. These lower results are a consequence of the failure to include lignin as fiber (15,38). Lignin and components in food that are extracted as lignin are present in relatively high amounts in whole grains, brans, and some fruits (25,28–32). The general consensus is that lignin should be included as part of dietary fiber (14,15) because it may have a role in the relationship between diet and colon cancer (44). Two other aspects of the Englyst method may be responsible for some of the differences in his data versus those obtained by other methods (15). The DMSO that is used to solubilize starch may also solubilize fiber polysaccharides, which would be lost to subsequent analysis. Second, acid hydrolysis conditions may be insufficient to hydrolyze all fiber polymers to their monomeric units and, thus, would not be detected by GC.

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