Comparison of Dietary Fiber Contents of Selected Baby Foods from Two Major Brands in Canada Using Three Methods

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Of the two major brands of baby foods in Canada, one reports lower dietary fiber values than the other, although the products appear to be similar. To investigate the reasons for this discrepancy, seven selected samples of baby foods from both brands were analyzed for total dietary fiber (TDF) according to the Mongeau (rapid Health Protection Branch; HPB) method. Two cereals were also analyzed by using the Prosky and the Englyst (nonstarch polysaccharide; NSP) methods as an internal check on the methodology as well as a means of investigating the reasons for the discrepancies. The sampling included at least four different lots of each product (cereals, fruits, vegetables, and legumes). Each lot was analyzed individually. The TDF values determined using the rapid HPB method were in agreement with those obtained by other dietary fiber methods. Comparison between manufacturer-reported and measured values showed that the low values reported in brand A products were due, in part, to under-reporting of TDF content: measured TDF values were significantly higher than manufacturer-reported values. For brand B products, the manufacturer-reported and measured TDF values were in general agreement. This shows that a large part of the discrepancy between the two brands was due to methodological problems associated with measuring TDF in brand A. Differences in TDF content were also apparent as shown by the fact that brand A TDF values were consistently lower than those of brand B when both were measured by the same method. The differences in TDF content were not explained by differences in the polysaccharide composition of the fiber residues or by differences in water content. Although the limited number of samples does not allow any general conclusion about the TDF content of specific brands, the results show that formulation and/or manufacturing differences may influence TDF values in processed baby foods.

Keywords: *Baby; dietary; fiber; foods; HPB; NSP*

INTRODUCTION

There are many different brands of baby foods on the Canadian market. However, in many instances, the foods appear to be similar in composition but have widely different food compositional data. This is puzzling as baby foods sharing equivalent names, but coming from different companies, should contain similar ingredients. A tacit implication is that they also have similar total dietary fiber (TDF) contents. This is apparently not the case because TDF values reported by two leading brands, brands A and B, differ by as much as 7-fold for equivalent products.

The discrepancy in the TDF values reported by brands A and B could reflect real differences between the products and/or a methodological problem. It is important to know the correct dietary fiber content of baby foods so that proper data are provided for estimating nutrient intakes, assessing disease risks, and establishing nutrition recommendations. The aim of this work was to compare reported and measured TDF values of selected brand A and B products to assess potential methodological problems and/or differences between brands. This study also allowed us to assess the need for new TDF data for baby foods. To this end, seven equivalent baby food products from brands A and B were collected and analyzed for total dietary fiber.

EXPERIMENTAL PROCEDURES

The baby foods were purchased in 1996 in the Ottawa region. Food samples from at least four lots were purchased. Expiration dates were used as the basis for lot selection. Food was freeze-dried and milled in a Wiley mill using a 0.85 mm screen. Foods containing >5% fat were defatted at room temperature using acetone. The dry powder was stored at −20 °C until analysis. Storage time was <30 days.

Unless otherwise indicated, TDF was analyzed using the Health Protection Branch (HPB) rapid gravimetric method LPFC-162 (*1*). This method sequentially analyzes soluble and insoluble fiber fractions according to AOAC Method 992.16, Final Action 1997 (*2*). The residue left after the measurement of soluble fiber was used to measure insoluble fiber. In this procedure, the neutral detergent extract is treated with unpurified pancreatic α-amylase, which contains proteases (Sigma, catalog no. A3176) to efficiently digest starch and digestible protein. The insoluble fiber residue includes cellulose, hemicelluloses, lignin, and undigestible (mostly structural) protein, but it excludes slowly digestible starch. The

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method is termed "rapid" because it does not include a separate nitrogen determination to back-correct the final insoluble dietary fiber (IDF) residue for protein content. The TDF values obtained with the above procedure are close to those determined with the Prosky method for unprocessed foods (*3*, *4*), and they are not altered by processing of the foods (*3*).

Barley cereal and fruit salad were analyzed using two different methods: the HPB method (described above) and the Prosky method (AOAC 985.29, Sigma kit TDF-100A, Sigma Chemical Co., St. Louis, MO). These foods represent two samples that should differ widely in their soluble dietary fiber contents. In the Prosky method, the protein in the sample is only partly digested. This necessitates the inclusion of a separate nitrogen determination to calculate the amount of residual protein. The protein value is then subtracted from the residue weight to give a protein-corrected TDF value. In addition to this difference between the HPB and Prosky methodologies, the TDF values for some foods determined using the Prosky method may include variable amounts of slowly digested starch as well as resistant starch.

Barley and rice cereals were also analyzed according to the Englyst method (*5*). The nonstarch polysaccharides (NSP) obtained in the final step of the Englyst method were analyzed by gas−liquid chromatography using a wide-bore capillary column. We added the dimethyl sulfoxide (DMSO) treatment recommended by Englyst to gelatinize (and remove) all starch from the final NSP isolate. All enzymes for this method were provided by Englyst. NSP values exclude lignin and all protein.

The TDF values are reported as grams per 100 grams of food on an "as is" basis. However, some comparison of the foods on a "ready-to-eat" basis was also required so the weight of cereal in 100 g of prepared cereal (dry plus liquid) was calculated according to three different methods: (i) by assuming 16.4 g of dry cereal per 100 g of prepared cereal (brands A and B; *6*); (ii) by assuming 9.7 g of dry cereal per 100 g of prepared cereal (brands A and B; average of ready preparation and microwave preparation as directed by the manufacturers on the cereal boxes); or (iii) by assuming either 15.4 g (brand A) or 25.4 g (brand B) per 100 g of prepared cereal. The latter method represents the average of $n = 10$ individuals who were asked to prepare cereal without specific directions. When required, the densities of the dry cereals were obtained from the Canadian Nutrient File (*7*): 0.212 g/mL (barley, brands A and B), 0.189 g/mL (rice, brand A), and 0.235 g/mL (rice, brand B).

Values are reported as mean ± standard deviation (SD). The types of statistical comparisons are reported in the legends to the individual tables. Details on the models used for the ANOVA analyses are included in the table legends. The advantage of a nested design is that variability among lots is accounted for in the analysis. This improves the sensitivity for testing among methodologies. All tests were performed using Statistica v. 5.0 (Statsoft Inc., Tulsa OK) after transformation of the fractional values (in grams per 100 g of food) by $\arcsin(\sqrt{y})$ to normalize the data distribution.

RESULTS

Differences among the three TDF methodologies used in the present paper (HPB rapid, Prosky, and Englyst) often manifest as differences in TDF values. This occurs because of method-specific variations in enzymes and incubation conditions. In addition, some methods include or exclude dietary fiber components such as lignin and cutins in the final TDF value. These methodological differences translated into differences in TDF values as measured on an as is basis, but the magnitude and direction were not consistent for all foods. For example, TDF values measured for barley cereal followed the order HPB ≈ Prosky > Englyst, whereas for rice cereal the TDF values followed the order HPB > Prosky > Englyst (Table 1). On the other hand, methodological differences did not explain brand-specific differences in TDF; all three methods reported a significantly lower barley cereal TDF content in brand A as compared to brand B (Table 1). This observation was also noted for strained fruit salad when different lots were assayed using the HPB and Prosky methods, suggesting that different formulations were used by the different manufacturers: brand A, 0.25 ± 0.03 g/100 g as is (HPB and Prosky methods); brand B, 1.41 ± 0.05 g/100 g as is (average of HPB and Prosky methods). The differences between brands cannot be explained by differences in moisture content because the strained fruit salad products had similar water contents (82−84%); the TDF differences would remain when expressed on a dry matter basis.

Table 1. Total Dietary Fiber (TDF) Values Determined in a Single Lot of Barley or Rice Cereal from Different Brands: Methodological Comparison

		g/100 g of food on an as is basis[a]			
food	brand	moisture[b]	TDF HPB[c]	TDF Prosky[d]	NSP[e]
barley	A	5.2	8.5 ± 0.4[a]	8.3 ± 0.1[a]	7.3 ± 0.2[b]
	B	5.8	11.3 ± 0.1[c]	11.0 ± 0.1[c]	10.1 ± 0.3[d]
rice	B		2.7 ± 0.2[e]	1.8 ± 0.1[f]	1.2 ± 0.1[g]

[a] Values from fiber determinations represent mean ± SD for $n = 3$ samples from a single lot of baby food. Because of this design, statistical significance was assessed by using a nested ANOVA analysis with the different methodologies representing the nested factor. Comparisons between methodologies were, therefore, performed using linear comparisons. Values with different superscripts within one row are significantly different at the $P < 0.001$ level. For brand comparison using barley cereal, brand A was significantly lower than brand B ($P < 0.005$). [b] Moisture represents a single determination on the dry food from the manufacturer. [c] HPB gravimetric method: AOAC 992.16, sequential. [d] Prosky gravimetric method: AOAC 985.29. [e] NSP, nonstarch polysaccharides by Englyst chemical method using gas−liquid chromatography; NSP excludes lignin.

Table 2 presents the soluble dietary fiber (SDF), insoluble dietary fiber (IDF), and TDF ± standard deviation for seven products analyzed according to the HPB method. The data show an appreciable amount of TDF (>1 g/100 g of food on an as is basis) in peas and mixed vegetables. Brand B fruit salad contained appreciable amounts of fiber, but the same food from brand A had only minor amounts. The vegetable and chicken and beef stew foods contained <1% TDF regardless of the brand. Although barley and rice cereals contained significant amounts of fiber on a dry weight basis, addition of water (or milk) to these foods appreciably decreased the fiber content on a "ready-to-eat" basis; barley cereal would contain between 0.7 and 1.2 g of TDF (brand A) or 1.0−2.6 g TDF (brand B) per 100 g of prepared cereal. Similar calculations for rice cereal predicted 0.14−0.28 g of TDF (brand A) or 0.22−0.53 g of TDF (brand B) per 100 g of prepared cereal.

The data of Table 2 also demonstrate that, to a large extent, differences in TDF values between brands (A versus B) were related to differences in IDF values rather than differences in SDF; differences in IDF accounted for between 50% (vegetable and chicken dinner) and 150% (rice cereal) of the difference in TDF. Generally, brand A products contained less TDF than the corresponding brand B products: brand A contained on average 66% of the fiber found in brand B (excluding peas from the calculation). Large differences were, however, noted between foods: percentages varied from 18% in fruit salad to 90% in mixed vegetables. Peas were the exception to this trend: brand A contained

Table 2. Soluble, Insoluble, and Total Dietary Fiber Contents of Baby Foods

			g/100 g of food on an as is basis[a]				
sample	brand	n	H_2O[b]	SDF/IDF	TDF ± SD	TDF range	manufacturer-reported TDF
barley cereal, dry	A	4	3.8	4.8/2.4	7.2 ± 0.42	6.83−7.62	3.7
barley cereal, dry	B	4	4.4	5.5/5.1	10.6 ± 0.74	9.67−11.2	10.5
rice cereal, dry	A	5	3.5	0.4/1.3	1.7 ± 0.15	1.40−1.80	0.5
rice cereal, dry	B	4	4.3	0.2/1.9	2.1 ± 0.10	1.97−2.17	1.9
fruit salad, strained	A	5	83.9	0.2/0.1	0.25 ± 0.03	0.21−0.29	≤0.1[c]
fruit salad, strained	B	4	81.6	0.6/0.8	1.41 ± 0.07	1.31−1.46	1.0
mixed vegetables, junior	A	5	89.1	0.6/0.6	1.26 ± 0.03	1.23−1.30	0.4
mixed vegetables, junior	B	5	89.8	0.6/0.8	1.4 ± 0.10	1.24−1.46	1.8
peas, strained	A	5	87.5	0.7/1.8	2.48 ± 0.06	2.42−2.57	1.1
peas, strained	B	5	89.8	0.7/1.5	2.2 ± 0.10	2.01−2.28	3.1
vegetables and chicken, strained	A	5	92	0.2/0.2	0.35 ± 0.02	0.33−0.37	0.1
vegetables and chicken, strained	B	5	87	0.3/0.3	0.56 ± 0.06	0.49−0.63	0.5
beef stew, junior	A	5	87.4	0.3/0.3	0.56 ± 0.05	0.50−0.63	0.2
beef stew, junior	B	5	84.8	0.3/0.4	0.72 ± 0.04	0.66−0.76	1.4

[a] Values represent mean ± SD for n (number of lots) indicated values. The values are the means of two separate determinations for each lot. Except for "mixed vegetables, junior", the TDF values for brand A were significantly different from those for brand B at the $P < 0.006$ level (determined by 2 × 7 ANOVA on individual cereals). [b] H_2O, moisture; SDF, soluble fiber; IDF, insoluble fiber; TDF, total dietary fiber. [c] Manufacturer indicated that the TDF value was below detection. A value of 0.1 was, therefore, used in the correlation plot of Figure 1.

Table 3. Nonstarch Polysaccharide Composition of Barley Cereals As Determined by the Englyst Methodology Using Gas−Liquid Chromatography

	g/100 g of NSP[a]	
constituent sugar	brand A	brand B
arabinose	13.4 ± 0.1	15.3 ± 0.2
xylose	22.3 ± 0.4	24.7 ± 0.3
glucose[b]	55.0 ± 0.7	50.2 ± 1.1
mannose	2.8 ± 0.1	2.8 ± 0.1
other neutral sugars	4.0 ± 0.1	4.8 ± 1.0
uronic acid	2.5 ± 0.3	2.5 ± 0.1

[a] Values represent means ± SD for $n = 3$ separate determinations. [b] Significantly different as calculated by ANOVA on transformed data followed by linear comparison ($P = 0.02$).

113% of the TDF found in brand B. Statistical differences between brands were noted for all foods with the exception of mixed vegetables (Table 2).

Differences between TDF values in different brands may have resulted from differences in formulations and/or from differences in absolute concentrations of ingredients. Differences in formulations between brands for barley cereal were indirectly assessed by comparing carbohydrate residue percentages obtained from the NSP methodology (Table 3). Glucose (from hydrolyzed β-glucans and cellulose), xylose, and arabinose represented ∼90% of barley NSP in brands A and B. Statistical comparisons between barley cereals from brands A and B showed only a minor significant difference in the percentage of glucose: brand A had more glucose than brand B. No other differences were noted between brands.

In addition to differences between brands, discrepancies between measured and reported TDF values were also noted (see Table 2). To examine the nature of these discrepancies, measured TDF values were plotted as a function of reported TDF values for products of brands A and B (Figure 1). The regression parameters are shown in the legend to Figure 1. The slope of the relationship for brand A (1.89 ± 0.04) was significantly different from 1.0 ($P < 0.00001$, Student's t test), suggesting methodological differences rather than a constant error term were responsible for the discrepancies between measured and reported TDF values. On the other hand, the slope of the relationship between measured and reported TDF values in samples from

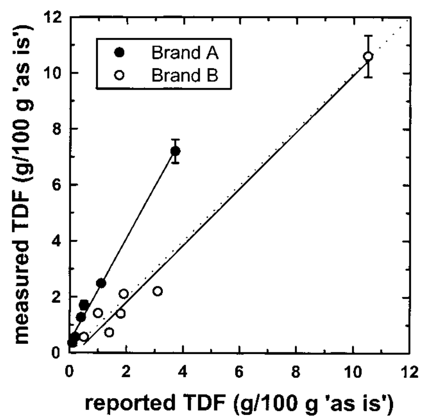

Figure 1. Relationship between measured and reported TDF values in brands A and B. Measured TDF values (from Table 2) were plotted as a function of the manufacturer's reported TDF values for brand A (solid circles) and brand B (open circles). The solid lines represent the least squares regression fit of the data. The dotted line represents the relationship expected if an exact correlation existed between reported and measured data. Regression analysis gave slopes of 1.89 ± 0.04 (brand A) and 0.96 ± 0.03 (brand B). Intercepts were 0.33 ± 0.06 (brand A) and 0.34 ± 0.12 (brand B). The slope of the line describing brand A was significantly greater than 1.0, whereas that for brand B was not. The absence of error bars indicates that the variance of the measurement was smaller than the size of the symbol.

brand B (0.96 ± 0.03) was not significantly different from unity, suggesting no differences in methodology existed. The intercept of the regression for brand B (0.34 ± 0.12) was significantly different from 0.0 ($P < 0.00785$), suggesting a constant bias exists for TDF values reported for brand B.

The slope of the relationship between measured and manufacturer-reported TDF values observed for brand A (Figure 1) implies that the discrepancy may be related to methodological differences. We directly compared the TDF values measured by the HPB and Prosky methods because the Prosky method is commonly used by industry to measure TDF. Table 1 presents a preliminary comparison of methods for barley cereal (on a single, pooled sample). These results demonstrate that similar TDF values were obtained with the Prosky and HPB methods. The values obtained with strained fruit (see above) support this observation: both methodologies gave identical results in samples from four different lots. In addition to a methodological comparison, Table 2 rules out variability between lot numbers as a reason for the difference between measured and reported TDF values because the standard deviation of the determinations was relatively small: the coefficients of variation were 12% for brand A and 2−5% for brand B (depending on the method used).

DISCUSSION

Insoluble fiber represents at least two-thirds of TDF in a mixed diet (*8*), and it is expected that a mixed baby food diet should not deviate from this proportion. The baby food samples measured in the present paper were low in IDF content as a general rule, and particular samples were especially low. For example, IDF represented only one-third of the TDF in barley cereal from brand B and in strained fruit salad from brand A. In the rest of the products, IDF represented approximately half of TDF. The relatively low proportion of IDF in these foods may be due to the effects of processing. Processing has been known to depolymerize insoluble fiber, and this could lead to an apparent increase in the proportion of soluble fiber (*9*). A difference in the proportion of insoluble fiber may also be due to a different selection of fiber source between brands A and B. In the case of barley, however, this appears to be unlikely because analysis of the constituent components of the NSP fraction of brands A and B showed essentially identical results (Table 3).

There has been a recent trend toward recommending increased fiber intake in infants (*10*) to levels similar to those of some European countries (*11*). It has been suggested that infants eat an amount of TDF equivalent to 5 g plus their age in years daily. This means that infants eating these foods should consume between 5 and 6 g of dietary fiber per day. From the present small sampling of the available baby foods, it is possible to roughly estimate the difficulty in meeting these recommendations. To do this, we calculated the percentage of total calories that must come from infant foods such as those of Table 2 in order to meet these dietary fiber target intakes. The calculations maintained the proportion of cereal, vegetable, and fruit actually ingested by infants as estimated from infant energy intakes (*12*). Using the TDF values of Table 2 as examples of each food category, it was possible to estimate that infants must eat ∼230 kcal of energy from baby food to meet the suggested TDF requirements. This represents ∼25% of the total caloric intake recommended for infants between 5 and 12 months of age (*13*) and ∼25% of the median energy intake of infants between 5 and 12 months of age (*12*). Recent data from the United States (*12*) indicate that infants consume an average of approximately half of their calories from formula with the other half coming from infant foods (20%) and noninfant foods (30%). Approximately 15% of total energy intake comes from infant cereals, fruit and juice, and vegetables (*12*). Thus, the goal of 5 g plus age in years is easily attainable from infant foods with a slight change in eating habits. Because a substantial amount of dietary fiber (39% of the total) comes from noninfant foods, the goal could also be met by changing noninfant food selection to foods higher in dietary fiber. Note that the median TDF intake for these infants is 4.6 g/day (95th percentage upper and lower limits of 4.2 and 5 g/day; *19*), showing that the infant diets provide TDF intakes close to recommendations.

Of particular interest in the present paper was the relationship between reported and measured TDF values. Seven apparently equivalent products of brands A and B were selected to include several categories of baby foods. The results showed that the TDF values measured in brand B products were similar to their reported values. By contrast, the TDF values reported by brand A underestimated measured TDF values. The regression coefficient for measured versus reported TDF in brand A was 1.9, indicating that reported values were almost 2-fold lower than measured values. This difference was not related to our use of the HPB method to quantify TDF as shown by good agreements between the HPB and Prosky methods for TDF from barley cereal and fruit salad (Tables 1 and 2). A close association between the HPB method and the Prosky method has also been demonstrated for other food products (*3*, *4*, *14*, *15*). In addition, a comparison of TDF values obtained by the HPB method and the modified Uppsala method (*16*) demonstrated a close agreement between these latter two methodologies: regression analysis of TDF values for 45 foods (fruits, vegetables, cereals, and canned legumes) assayed by using the HPB method and the modified Uppsala method (*16*) gave a slope of 0.99 and an intercept of 0.06 ($r = 0.96$; unpublished data).

A surprising secondary result was observed when brands of baby foods were compared. In almost all cases, brand B foods were higher in TDF than brand A foods. These results, however, should not be taken as indicating that the products of one brand provide more TDF than those of another brand. This caveat is necessary because of the relatively small sample size in the present paper and the fact that one of the TDF values was higher: brand A peas contained more TDF than brand B peas. We attempted to investigate the reasons for this surprising result by comparing the dietary fiber sugar residues (Table 3) and moisture contents of foods from both brands. The results suggest that processing differences may be partly responsible for these differences. This was shown by similar water contents and sugar residue profiles (Table 3), suggesting that similar ingredients are present in both brands. Processing has been known to affect the distribution of fiber between insoluble and soluble fractions (*9*), promoting the accumulation of apparent soluble fiber. This additional soluble fiber is partly degraded insoluble fiber that does not provide oat gum-like physiological effects. Processing may also reduce TDF by decreasing the size of both IDF and SDF to reduce the total amount of precipitable material at the ethanol precipitation step. It is, however, difficult to rationalize the effect of processing on TDF without knowing the details of the process. For example, hydration and cooking of legumes has no apparent effect on the TDF content (*17*, *18*), although this depends on the methodology used to measure TDF (*15*). Cereals are most prone to losses in TDF during milling (*19*), but peeling and processing of vegetables and fruits can also lead to a loss in TDF (*19*). Some of the differences observed in the present limited sampling may be due to differences in peeling of fruits and sieving of larger particle sizes during processing. This remains to be determined.

The present results have implications for individuals managing nutrition databases. Clearly, averaging reported TDF values for equivalent products of brands A and B would not provide an adequate mean dietary fiber value for the Canadian Nutrient File. In some cases, products with the same name but from different manufacturers had different TDF values. In addition, one of the brands reported incorrect TDF values. Because inadequate databases (often derived from values provided by companies) prevent realistic assessments of nutrient intakes and disease risks, it is in everyone's best interest to ensure that problems are identified and addressed. It should be noted that some of the products analyzed in the present work were reformulated after our sample collection in 1996. It would be interesting to see how reformulations have changed the dietary fiber content and quality of baby foods.

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