# Dietary Fiber Content in Cereals in Norway

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**ABSTRACT**

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To investigate the content and variability of dietary fiber in cereals, whole-grain rye flour and four different milling fractions of wheat were collected from each of the nine mills in Norway. Soluble and insoluble dietary fiber was determined with an enzymatic method corresponding to the physiological definition of dietary fiber (sum of nondigestible polysaccharides and lignin). The average values of the different products were 3.6% for wheat flour, 14.4% for whole-grain wheat flour, 52.2% for wheat bran type 1 (including both outer layers and germ), 59.3% for wheat bran type 2 (almost only outer layers), and 16.8% for whole-grain rye flour. Considerable variation was found in the dietary fiber content of flours from different mills, whereas that of brans was almost constant.

Diet, nutrition, and health are connected. Even though the diet in Norway must be considered nutritionally adequate, generally covering the required essential nutrients, significant negative changes have occurred over the last 75 years (Anonymous 1975). One reason is that the consumption of cereals and potatoes has declined drastically. Consequently, carbohydrate content in the diet has decreased and the carbohydrate composition has changed. The decrease has been particularly great for starch. The consumption pattern, as elsewhere in the Western countries, has tended toward more refined food. Not only are Norwegians consuming less cereals, but the cereal products are, to a larger extent, made from refined white flour, depleted in dietary fiber and in essential nutrients like vitamins and minerals.

In recent years, the importance of dietary fiber in the diet has been extensively investigated (Kay and Strasberg 1978, Kelsey 1978). Accumulating evidence indicates that dietary fiber constituents have several important beneficial effects. Fiber is a well-recognized remedy for constipation, but it also has prominent effects upon lipid and carbohydrate metabolism that might be of importance in the prevention of atherosclerotic diseases and diabetes. Colonic cancer is another "Western" disease in which lack of dietary fiber has been suggested to be one pathogenetic factor. In Norway, two considerable changes in dietary fiber intake have

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occurred recently. First, the total intake has been reduced to about half during the last 70 years (Trygg 1976). Second, the fiber composition has changed. Earlier, cereals were the prominent source of fiber, whereas today fruit and vegetables are the main contributors. The same development is true for Great Britain (Bingham et al 1979). This is significant because fiber from different sources has different physiological properties.

For many, bran has become almost synonymous with fiber. It is the most concentrated form of fiber and is readily and cheaply available to the public from a variety of commercial sources. It is also a well-studied product, for most investigations on physiological effects have been made with bran as the source of fiber. In addition to its high fiber content, bran is also a good source of minerals and vitamins.

Cereal fiber intake could easily be increased by greater consumption of unrefined cereal products. The optimal amount of daily fiber intake has not yet been defined, however.

Knowledge about dietary fiber content in foodstuffs is interesting from a consumer's point of view. The definition and terminology of fiber are still under discussion. This is one reason for disagreement concerning the analysis of fiber. The crude fiber method, measuring only a small and variable fraction of the total dietary fiber, has now generally been abandoned (Southgate 1975, Van Soest and Robertson 1976). The neutral detergent fiber method, with amylase treatment, is considered to give a satisfactory measurement of insoluble components but does not measure water-soluble components such as pectin, gums, and some hemicelluloses (Southgate et al 1978). Fractionation methods with colorimetric or gas chromatographic quantification of dietary fiber constituents (Southgate 1976, 1977; Theander and Åman 1979) give important detailed information but are too laborious for routine purposes.

This article gives information on the fiber content in various cereal products as analyzed by an enzymatic gravimetric procedure corresponding to Trowell's definition of dietary fiber as the sum of undigestible polysaccharides and lignin (Trowell et al 1976).

**TABLE I**
**Dietary Fiber Content of Cereals[a]**

| | **Dietary Fiber (%)** | | |
|---|---|---|---|
| **Sample No.** | **Insoluble** | **Soluble** | **Total** |
| | **Wheat Flour** | | |
| 1 | 2.3 | 0.5 | 2.8 |
| 2 | 2.5 | 0.7 | 3.2 |
| 3 | 3.8 | 0.8 | 4.6 |
| 4 | 2.6 | 0.4 | 3.0 |
| 5 | 3.5 | 0.8 | 4.3 |
| 6 | 2.7 | 1.1 | 3.8 |
| 7 | 2.7 | 1.4 | 4.1 |
| 8 | 2.7 | 1.2 | 3.9 |
| 9 | 2.1 | 1.0 | 3.1 |
| Mean ± SD | 2.8 ± 0.5 | 0.8 ± 0.4 | 3.6 ± 0.6 |
| | **Whole-Grain Wheat Flour** | | |
| 1 | 12.6 | 1.3 | 13.9 |
| 2 | 13.3 | 1.5 | 14.8 |
| 3 | 11.3 | 1.0 | 12.3 |
| 4 | 17.5 | 0.4 | 17.9 |
| 5 | 11.8 | 1.8 | 13.6 |
| 6 | 10.8 | 1.1 | 11.9 |
| 7 | 11.2 | 0.8 | 12.0 |
| 8 | 15.1 | 1.8 | 16.9 |
| 9 | 15.1 | 1.3 | 16.4 |
| Mean ± SD | 13.2 ± 2.3 | 1.2 ± 0.5 | 14.4 ± 2.3 |
| | **Wheat Bran Type 1 (Millrun)** | | |
| 1 | 48.6 | 3.5 | 52.1 |
| 2 | 47.7 | 3.8 | 51.5 |
| 3 | 50.1 | 2.8 | 52.9 |
| Mean ± SD | 48.8 ± 1.2 | 3.4 ± 0.5 | 52.2 ± 0.7 |
| | **Wheat Bran Type 2 (Commercial)** | | |
| 1 | 54.5 | 2.7 | 57.2 |
| 2 | 53.5 | 3.8 | 57.3 |
| 3 | 55.6 | 3.7 | 59.3 |
| 4 | 59.0 | 3.2 | 62.2 |
| 5 | 54.0 | 3.3 | 57.3 |
| 6 | 56.9 | 3.8 | 60.7 |
| 7 | 57.1 | 3.7 | 60.8 |
| 8 | 55.4 | 4.0 | 59.4 |
| Mean ± SD | 55.8 ± 1.8 | 3.5 ± 0.4 | 59.3 ± 1.9 |
| | **Whole-Grain Rye Flour** | | |
| 1 | 12.4 | 2.2 | 14.6 |
| 2 | 12.3 | 2.6 | 14.9 |
| 3 | 15.8 | 2.4 | 18.2 |
| 4 | 15.8 | 1.1 | 16.9 |
| 5 | 15.5 | 2.4 | 17.9 |
| 6 | 11.3 | 2.6 | 13.9 |
| 7 | 13.7 | 3.3 | 17.0 |
| 8 | 12.4 | 1.6 | 14.0 |
| 9 | 18.2 | 5.1 | 23.3 |
| Mean ± SD | 14.2 ± 2.3 | 2.6 ± 1.1 | 16.8 ± 3.0 |

[a] Moisture free basis, corrected for protein, starch, and ash.

## MATERIALS AND METHODS

Norway, where the extraction rate is under governmental control, has a total of nine mills. Wheat was of primary interest in this study, rye to a lesser extent. The following samples were collected from each mill: 1) wheat flour (78% extraction, which is normal in Norway); 2) whole-grain wheat flour; 3) wheat bran type 1, defined as "millrun," the material left over after the milling process (22% of the whole grain, containing outer layers and germ); 4) wheat bran type 2, commercially found in markets and bakeries (about 15% of the whole grain, containing mostly outer layers); and 5) whole-grain rye flour.

### Sample Preparation

The samples did not contain more than about 5% lipids and were therefore not defatted (Schweizer and Würsch 1979). The samples were ground in a Cyclotec sample mill (Tecator) to a particle size of less than 0.45 mm.

### General Methods

Ash was determined by ignition at 550–600° C to constant weight (6 hr). The dry weights were determined by oven drying at 105° C to constant weight (18 hr). Unless otherwise indicated, weights and yields are stated on a moisture free basis.

### Dietary Fiber Method

The method used to determine the fiber content was based on Hellendoorn's enzymatic method (Asp and Johansson 1981,

**TABLE II**
**Ash Content and Total Fiber Content in Different Wheat Flours**

| **Wheat Flour No.** | **Ash Content[a]** | **Total Fiber[a]** |
|---|---|---|
| 1 | 0.63 | 2.8 |
| 2 | 0.54 | 3.2 |
| 3 | 0.66 | 4.6 |
| 4 | 0.45 | 3.0 |
| 5 | 0.48 | 4.3 |
| 6 | 0.43 | 3.8 |
| 7 | 0.58 | 4.1 |
| 8 | 0.64 | 3.9 |
| 9 | 0.64 | 3.1 |
| Mean ± SD | 0.56 ± 0.09 | 3.6 ± 0.6 |

[a] Percent of moisture-free flour.

Hellendoorn et al 1975) with the following modifications. The in vitro enzyme digestion was performed with pepsin at pH 1.5 for 1 hr and with pancreatin at pH 6.8 for 1 hr, thus simulating the conditions in the human gastrointestinal tract. Insoluble fiber components were recovered by filtration and soluble components by ethanol precipitation followed by filtration. The filtrations were carried out with Tecator's Fibertec system (Tecator AB, Höganäs, Sweden), using about 0.5 g of celite as a filter aid. The insoluble and soluble dietary fiber fractions thus recovered were dried overnight at 105°C before weighing. They were then analyzed for residual nitrogen by the Kjeldahl method (conversion factor to protein = 6.25). Remaining starch was also determined by measuring glucose following extensive glucoamylase digestion. Glucose was assayed with a TRIS-glucose oxidase reagent (Dahlqvist 1961). Starch, including dextrins and maltose, was assayed by measuring the increase in free glucose after incubation with $\gamma$-amylase (amyloglucosidase, Boehringer-Mannheim). Ash was determined as described above.

The dietary fiber values reported in the tables are the means of triplicate gravimetric analyses, corrected for remaining traces of starch, protein, and ash.

## RESULTS AND DISCUSSION

Dietary fiber content by the modified Hellendoorn's method is shown in Table I. The average values were 3.6% for wheat flour, 14.4% for whole-grain wheat, 52.2% for bran type 1, 59.3% for bran type 2, and 16.8% for rye flour.

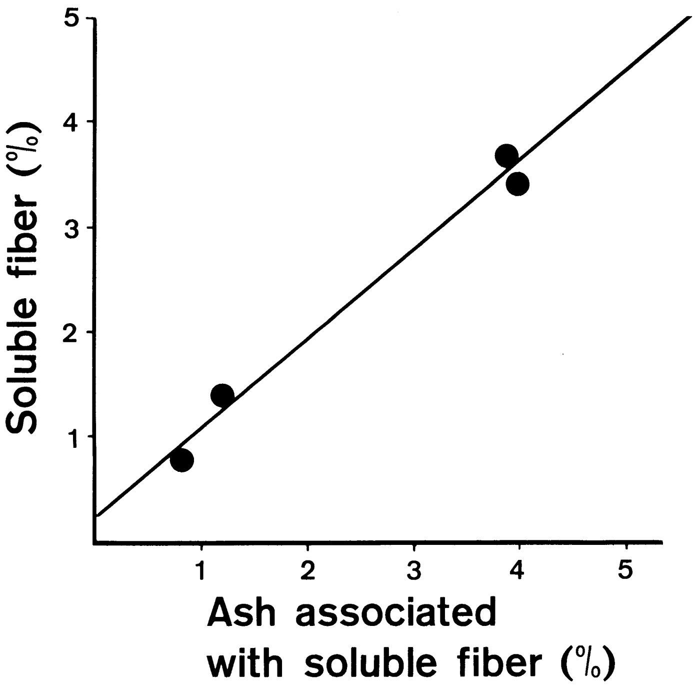


**Fig. 1.** Relation between soluble dietary fiber (corrected for ash) and the ash associated with it in four wheat products (percent of product on moisture free basis).

One of the advantages of this method, as compared with other gravimetric procedures, is that it measures soluble as well as insoluble components. The soluble fraction contributed 6–20% of the total fiber. This is probably the main reason that our figures are somewhat higher than usually found with other gravimetric methods (Anderson and Clydesdale 1980; Saunders and Mantala 1977, 1979).

Practically no data are available concerning the variability of dietary fiber content in cereals. In our materials, the two kinds of bran from different mills had very similar dietary fiber content. Considerable variations were found for whole-grain flours and also for wheat flours. The total dietary fiber in whole-grain wheat flour varied from 11.9 to 17.9% and that in whole-grain rye flour from 13.9 to 23.3%. The main reason for this may well be that Norway imports about 80% of its grain and that grain batches from different countries are mixed. Flours from the same mill probably vary in dietary fiber content from time to time. For food labeling, therefore, using an average value from all the mills for each type of flour is probably best.

The variation in dietary fiber content in white flours could also reflect actual variations in extraction rate. In Norway, this is supposed to be 78% and is adjusted according to the ash content. Nevertheless, differences were found in ash content from mill to mill, probably from technical adjustments during processing. No correlation existed between ash content and total dietary fiber content in our samples of wheat flour (Table II), indicating that the dietary fiber content of wheat flour cannot be predicted simply from the ash content.

The ash contents of the insoluble and soluble fiber fractions were also determined. The insoluble fraction, constituting 70–90% of the total dietary fiber, did not contain measurable amounts of minerals (ash). The soluble fiber fraction, on the other hand, contained minerals in amounts equal to the total mineral content of the product. A linear correlation was found between the amount of soluble fiber and the ash associated with it (Table III, Fig. 1). The nature of this association between soluble fiber and ash, also found by Schweizer and Würsch (1979), is under investigation.

Dietary fiber values were corrected for ash and for the residues of protein and starch remaining after enzyme digestion. The protein residues in the insoluble fraction of the wheat bran were close to 2% of the bran. Half of this, however, was due to the added enzymes, as shown by running an enzyme blank. The remaining 1%, corresponding to 2% of the dietary fiber, is probably truly indigestible protein associated with the fiber. In the soluble fraction, the corresponding protein residue (above the blank) was about 0.5%, corresponding to 10% of the water-soluble fiber. Whether nondigestible protein should be included as part of dietary fiber is an unresolved question. Saunders and Betschart (1980) recently claimed that protein is a component of dietary fiber. Our data, however, indicate that the fiber-associated, nondigestible protein is much lower than suggested by these authors (10%, versus a maximum of 3% according to our data). In the wheat flour fiber, almost no protein was detectable (above the blank), whereas in whole wheat flour, the residue amounted to about 3% of the total dietary fiber.

A starch residue of about 1% was found in all the flours but not in the brans. This residue, determined by extensive glucoamylase treatment, can be eliminated by including an additional step in the

**TABLE III**
**Dietary Fiber Content[a] (Corrected for Protein, Starch, and Ash) and Fiber-Associated Ash in Various Wheat Products**

| | Wheat Bran | | | | Flour | | | |
|---|---|---|---|---|---|---|---|---|
| | Type 1[b] | | Type 2 | | Whole-Grain | | Extracted | |
| | Fiber | Ash | Fiber | Ash | Fiber | Ash | Fiber | Ash |
| Total dietary fiber | 52.2 ± 0.7 | 4.0 ± 0.2 | 59.2 ± 1.5 | 4.0 ± 0.1 | 14.4 ± 2.0 | 1.3 ± 0.1 | 3.7 ± 0.6 | 0.7 ± 0.1 |
| Insoluble fiber | 48.8 ± 1.1 | 0 | 55.6 ± 1.4 | 0 | 13.2 ± 1.9 | 0 | 2.9 ± 0.4 | 0 |
| Soluble fiber | 3.4 ± 0.4 | 4.0 ± 0.2 | 3.6 ± 0.4 | 4.0 ± 0.1 | 1.2 ± 0.4 | 1.3 ± 0.1 | 0.8 ± 0.3 | 0.7 ± 0.1 |

[a]Mean ± standard deviation in percent of moisture-free material from nine different mills, each analyzed in triplicate.
[b]Obtained only from three mills.

final modification of the enzymatic fiber method.[3]

In conclusion, a gravimetric assay of soluble and insoluble residues following enzyme digestion gives an accurate and rapid estimate of dietary fiber content. The dietary fiber content of flours from different mills varied considerably, whereas that of brans was almost constant. Because of Norway's extensive importation of grain, the mixing of different grain batches, and the resulting variation in the flour produced, flour from the same mill may vary in dietary fiber content from time to time.

For food labeling, therefore, an average dietary fiber content from all the mills for each type of flour will probably be most adequate.

[3]N.-G. Asp., C.-G. Johansson, H. Hallmer, M. Siljeström. 1981. Unpublished data.

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