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Theander O & Åman P. Studies on dietary fibres. 1. Analysis and chemical characterization of water-soluble and water-insoluble dietary fibres. *Swed. J. Agr. Res.* 9:97-106, 1979.
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Fractions of water-soluble, dialyzed, and insoluble fibers were isolated from foodstuffs that had been extracted with 80 percent ethanol and chloroform and degraded with thermostable amylase. Neutral and acidic sugar residues were analyzed by gas liquid chromatography as alditol acetates and by decarboxylation, respectively. Lignin in insoluble fractions was determined gravimetrically. Dietary fibers were calculated as nonstarch polysaccharides and lignin in the two fractions and shown to have a wide variation in chemical composition in different foodstuffs. [The *SCI*® indicates that this paper has been cited in more than 135 publications, making it the most-cited paper from this journal.]

Informative Analysis of Dietary Fiber

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The value of fiber, especially from bran, in the human diet was recognized by the Greek Hippocrates in the fourth century BC. Since then, attention has been drawn occasionally to the importance of fiber, but generally with limited success. A lack of understanding of the chemical structure and analysis of plant cell walls prevented a more thorough nutritional evaluation. It was not until 1975, when D.P. Burkitt and H.C. Trowell suggested that many Western diseases were due to lack of fiber, that extensive research and development began.[1]

The understanding of the chemical composition and analysis of dietary fiber in food was mainly pioneered by D.A.T. Southgate, whose studies were based on the fractionation and colorimetric assay of hexose, pentose, and uronic acid constituents.[2] A meeting in 1977, organized by the European Economic Community and the International Agency for Research on Cancer of the World Health Organization, marked the starting point for efforts to introduce more modern and informative analytical methods to the field of dietary fiber.[3]

We realized that previous analytical methods, like the colorimetric and gravimetric techniques, had shortcomings since they were not specific for individual sugar residues of the fiber. Since each of us had a background in carbohydrate chemistry, one as a doctor of technology and professor in organic chemistry and the other as a relatively new agronomy doctor, we decided to try to develop a method, based on existing, modern knowledge in carbohydrate chemistry, for the analysis of dietary fiber.

We defined dietary fiber as nonstarch polysaccharides and lignin, since these components were known to be the major constituents of plant cell walls. This is a purely chemical definition, so it was possible to develop an analytical procedure to match it. Starch was efficiently degraded using a highly specific α-amylase (Termamyl) at 85° C, later used in other methods for dietary fiber—for example, the generally accepted gravimetric method of the Association of Official Analytical Chemists (AOAC).[4] Soluble fiber was extracted, together with low-molecular weight carbohydrates and hydrolyzed starch, and isolated by dialysis. The composition of the neutral sugar residues was determined, after acid hydrolysis, by gas liquid chromatography (GLC) as alditol acetates. Correction factors for hydrolysis losses, derivatization yields, and GLC-responses for the individual sugars were included in the method. For the analysis of uronic acid residues, we decided to use a decarboxylation method since this procedure does not suffer from the interference problems that are found with the commonly used colorimetric assays.

In the insoluble residue, lignin was determined gravimetrically as Klason lignin after sulfuric acid hydrolysis of the polysaccharides. When applied to human foods, however, the values obtained represent not only native lignin but also tannins, cutins, some proteinaceous materials, and, in heat-treated materials, products from the Maillard and caramelization reactions. These constituents of the Klason lignin most likely represent food components, which, like lignin, are unavailable to human enzymes. Klason lignin could therefore be designated as the "noncarbohydrate" part of dietary fiber. The amount of sugar and uronic acid residues (calculated as polysaccharides) in the water-soluble fraction and the same components plus Klason lignin in the water-insoluble fraction, respectively, provide a measure of the content of water-soluble and water-insoluble dietary fiber.

We believe that this method has been widely cited because it was based on modern knowledge in organic chemistry and analysis and was closely related to our chemical definition of dietary fiber. The upgraded method is referred to as the Uppsala method and is now going to be tested by AOAC in a collaborative study for official approval.[5,6]

1. **Burkitt D P & Trowell H C.** *Refined carbohydrate foods and disease. Some implications of dietary fibre.* London: Academic Press, 1975. 356 p. (Cited 245 times.)
2. **Southgate D A T.** Determination of carbohydrates in foods. II. Unavailable carbohydrates. *J. Sci. Food Agr.* 20:331-5, 1969. (Cited 205 times.)
3. **Theander O & James P.** European efforts in dietary fiber characterization. (Inglett G E & Falkehag S I, eds.) *Dietary fibers: chemistry and nutrition.* New York: Academic Press, 1979. p. 245-9. (Cited 25 times.)
4. **Prosky L, Asp N-G, Furda I, DeVries J W, Schweizer T F & Harland B F.** Determination of total dietary fiber in foods and food products: collaborative study. *J. Assn. Offic. Anal. Chem.* 68:677-9, 1985. (Cited 70 times.)
5. **Theander O & Westerlund E.** Studies on dietary fiber. 3. Improved procedures for analysis of dietary fiber. *J. Agr. Food Chem.* 34:330-6, 1986. (Cited 80 times.)
6. **Theander O, Åman P, Westerlund E & Graham H.** The Uppsala method for rapid analysis of total dietary fiber. *Advan. Experiment. Med. Biol.* 270:273-8, 1990.

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