Nutrition Labeling of Carbohydrates: Definition, Analyses, and Caloric Calculations

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Carbohydrates are composed of polyhydroxy aldehydes, ketones, alcohols, and acids of varying degrees of polymerization. They are categorized according to sizes into three classes: 1) Monosaccharides are the simplest of carbohydrates; examples are the hexoses - fructose, glucose, and galactose; and the sugar alcohols - mannitol, sorbitol, xylitol. 2) Oligosaccharides are polymers with 2 to 10 monosaccharide units; examples are the disaccharides - lactose, maltose, and sucrose; the trisaccharides - maltotriose and raffinose; and the tetrasaccharides - maltotetrose and stachyose; and 3) Polysaccharides are complex carbohydrates of polymers with 11 to thousands of monosaccharide units; examples are homopolysaccharides - starch and cellulose; and heteropolysaccharides - pectin and galactomannan.

For nutrition labeling purposes (1), carbohydrates are grouped and defined as follows: *Total carbohydrate*: total weight of food - (crude protein + total fat + moisture + ash); *Sugars*: free monosaccharides and disaccharides; *Sugar alcohols*: saccharide derivatives in which a ketone or aldehyde group is replaced by a hydroxyl group, and whose use in food is listed by FDA or is GRAS; *Dietary fiber*: defined according to AOAC method 985.29 and 991.43 with *soluble dietary fiber* and *insoluble dietary fiber* defined according to AOAC method 991.43; and *Other carbohydrates*: total carbohydrate -(dietary fiber + sugars + {sugar alcohol}).

Chromatographic methods have been developed for the separation and quantification of individual sugars and sugar alcohols in foods. Presently, there are several high-performance liquid chromatographic (HPLC) methods which have been adopted by AOAC for the analysis of honey, corn sirup (sic), milk chocolate, and presweetened cereal. Two gas-liquid chromatographic (GLC) methods are also listed as official methods for fruit juices, apples, and apple by-products, as shown in Table 1. A general discussion of these chromatographic methods may be found in the Proceedings of the 11th National Nutrient Databank Conference (2). Whether HPLC or GLC technique is used for sugar determination, sample preparation and extraction procedures still need to be collaboratively studied for a number of food matrices.

Physiologically, dietary fiber is defined as that component of food which consists of remnants of the plant cells resistant to hydrolysis by the alimentary enzymes of humans. Chemically, it may be regarded solely as the nonstarch polysaccharides or nonstarch polysaccharides plus lignin. Gravimetrically, it is the residue that remain after enzymatic treatment of a food sample minus residual crude protein and ash. The last definition is the basis for the nutrition labeling regulations. The two enzymatic-gravimetric methods, AOAC method 985.29 and 991.43, are recognized by FDA as the official methods (3) for determining dietary fiber and its soluble and insoluble fractions. Both methods utilize a heat stable α-amylase and an amyloglucosidase for the removal of starch and a protease for protein hydrolysis in aqueous medium, which is phosphate buffer for method 985.29 and MES-Tris buffer for method 991.43. For foods containing very little or no starch, e.g. most fruits and vegetables, a nonenzymatic-gravimetric method (4) has been approved by the AOAC Methods Committee and was adopted as first action by AOAC Methods Board in May 1993. In this method, which requires no enzyme treatment, samples are suspended in deionized water and diluted with 95% ethanol to yield, after correction for crude protein and ash, total dietary fiber values comparable to those using the official methods.

Caloric values of foods are generally calculated from the amounts of protein, fat, and carbohydrate in the foods using energy conversion factors, expressed as kcal/g or kJ/g. With the emerging status of various carbohydrates in nutrition labeling, calorie calculations need to be reexamined. For regulatory purposes, five options have been provided for the calculation of caloric

content of foods. They are 1) specific Atwater food factors, 2) general factors of 4, 4, and 9 calories per gram of protein, total carbohydrate including dietary fiber, and fat, respectively, 3) same as 2) except that insoluble dietary fiber content may be subtracted from total carbohydrate content, 4) specific factors for particular food ingredients petitioned by manufacturers/users and approved by FDA as appropriate, and 5) bomb calorimetry data after subtraction of 1.25 calories per gram of protein.

A sample of reduced-calorie white bread and another of pork and beans were analyzed for the various carbohydrate fractions as specified in the labeling regulations. Using the analytically determined carbohydrate data and the label information on serving sizes, fat and protein contents, the caloric values for these products were calculated using the different options, including an additional one which has long been used in the United Kingdom (5). Summaries of the results are given in Table 2 and 3. For a processed food such as pork and beans, the calculated caloric values ranged from 170 to 310. Such discrepancy would be expected for most foods that contain relatively high level of dietary fiber.

Many issues concerning carbohydrates for nutrition labeling are still under discussion. For example, should the term "complex carbohydrate" be resurrected, and if so, how should it be defined? Do all analytically determined "soluble dietary fiber" have the same physiological effects? What is the caloric content of various dietary fibers from different sources?

Table 1. AOAC Approved Chromatographic Methods for Sugar and Sugar Alcohol Determination

Method	Method Type	Foods	Analytes
977.20	HPLC	Honey	Fructose, Glucose and Sucrose
979.23	HPLC	Corn Sirup	Fructose, Glucose, Maltose and Maltotriose
983.22			DP_2 & DP_3
980.13	HPLC	Milk Chocolate	Fructose, Glucose, Lactose, Maltose, and Sucrose
982.14	HPLC	Presweetened Cereals	Fructose, Glucose, Maltose, and Sucrose
984.17		Licorice	
971.18	GLC	Fruit Juices	Fructose, Glucose, Maltose, and Sorbitol
973.28	GLC	Apples and Apple By-products	Sorbitol

Table 2. REDUCED-CALORIE WHITE BREAD—Serving size 1.0 ox (28.3 g); Total dietary fiber, 2.82 g; Insoluble dietary fiber, 2.34 g; Available carbohydrate, 9.65 g

	gram/serving	calories				
		I	II	III	IV	V
Protein	2.47	9.88	9.88	9.88	9.88	9.88
Fat	0.71	6.39	6.18	6.39	6.39	6.39
Carbohydrate	12.6	*39.1*	*42.8*	*50.4*	*41.0*	*36.2*
Total Calories		55.4	58.9	66.7	57.3	52.5

I – protein x 4; fat x 9; (carbohydrate — dietary fiber) x 4
II – protein x 4.0; fat x 8.7; carbohydrate x 3.4
III – protein x 4; fat x 9; carbohydrate x 4
IV – protein x 4; fat x 9; (carbohydrate — insoluble dietary fiber) x 4
V – protein x 4; fat x 9; available carbohydrate x 3.75 [U.K.]

Table 3. PORK AND BEANS – Serving size, 8 oz (227 g); Total dietary fiber, 10 g; Insoluble fiber, 6.8g; Available carbohydrate, 29.8 g

	gram/serving	calories					
		I	II	III	IV	V	VI
Protein	9	36	32	36	36	36	—
Fat	3	27	26	27	27	27	—
Carbohydrate	44	*136*	*172*	*176*	*149*	*111*	—
Total calories		199	230	239	212	174	310

I – protein x 4; fat x 9; (carbohydrate — dietary fiber) x 4
II – protein x 4.0; fat x 8.7; carbohydrate x 3.4
III – protein x 4; fat x 9; carbohydrate x 4
IV – protein x 4; fat x 9; (carbohydrate — insoluble dietary fiber) x 4
V – protein x 4; fat x 9; available carbohydrate x 3.75 [U.K.]
VI – bomb calorimetry value – 1.25 calorie x gram of protein

References

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