Dietary Fiber Content of Barley Grown in Finland

T. AALTO,[1] M. LEHTONEN,[2] and P. VARO[1]

ABSTRACT

The dietary fiber content in 118 samples of two- and six-rowed Finnish barley varieties grown in three different locations was determined gravimetrically as the sum of water-insoluble and water-soluble dietary fiber. Total dietary fiber content of the individual varieties ranged from 15.0 to 24.1%, water-insoluble dietary fiber from 11.1 to 19.2%, and water-soluble dietary fiber from 3.3 to 5.9%. The mean total dietary fiber of the two-rowed varieties (19.9%) was slightly lower than that of the six-rowed varieties (20.9%). One-fourth of the total dietary fiber in the two-rowed and one-fifth in the six-rowed varieties was water soluble. The location of growth had only a minor effect on the fiber content of barley.

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Barley is the main cereal grown in Finland. Although its consumption by humans is low, the share of industrially prepared feeds used in animal production has been increasing, and barley is one of the basic raw materials. Barley grows well even in the northern agricultural areas and, as a raw material, it is cheaper than wheat. Intensive research is being done on barley to find uses for all parts of the grain.

The purpose of this study was to determine the dietary fiber content of 100 genetic barley lines grown in three different locations in Finland. A diet high in dietary fiber has been shown to decrease the occurrence of some diseases in the digestive tract (Burkitt et al 1972). A fiber-containing barley fraction is a by-product of alcohol production and, in addition to use in animal feeds, it is considered as a potential raw material for the food industry.

MATERIALS AND METHODS

Barley Varieties

Two- and six-rowed barley varieties, altogether 100 genetic lines, were grown by the Hankkija Plant Breeding Institute, Hyrylä, Finland. The 118 growing experiments were done in 1983 on three farms in Finland representing the southern, central, and northern agricultural areas of the country. The growing locations were Anttila Experimental Farm at 60°42′N 25°03′E, Nikkilä Experimental Farm at 61°55′N 24°23′E, and Viskaali Trial Fields at 64°82′N 25°98′E. The samples from this growing experiment were used in the present study.

Sample Pretreatment

Barley grains were stored in a silo after harvest. No parts of the grain were removed; however, most of the awns had fallen off during handling. Whole barley grains were ground to pass a 0.5-mm sieve with Tecator's Cyclotec 1093 sample mill. The dry matter of the grains was determined as the weight after 3 hr in a 105°C oven. The weight of 1,000 grains was determined by the Hankkija Plant Breeding Institute.

Analytical Methods

Dietary fiber content was determined according to Asp et al (1983). The method determines both water-insoluble and water-soluble dietary fiber, whereas the AOAC method (Prosky et al 1984) gives plain total dietary fiber. There are minor differences in incubation times and enzymes between these two methods. Because there was interest in the water-soluble dietary fiber fraction, the Asp et al (1983) method was chosen.

Water-insoluble and water-soluble dietary fiber were determined using Tecator's Fibertec E-Dietary Fibre Analyzer. Duplicate 1-g samples were weighed with an accuracy of 0.1 mg and transferred to 500-ml polycarbonate flasks. Sodium phosphate (25 ml, 0.1*M*, pH 6.0) was added and the sample was suspended. Termamyl 120L (100 μl, Novo industri AS) was added, the tops of the flasks were covered with aluminum foil, and the flasks were incubated at 100°C for 15 min with occasional shaking. After the flasks were cooled, 20 ml of distilled water was added and the pH was adjusted to 1.5 with 4*M* HCl. Pepsin (100 mg, pepsin from hog stomach, 77163, Fluka AG) was added; then the flasks were covered and incubated in a 40°C water bath with agitation for 60 min. After the flasks were cooled, distilled water (20 ml) was added, and the pH was adjusted to 6.8 with 4*M* NaOH. Pancreatin (100 mg, Pancreatin P-1750, Sigma Chemical Co.) was added, and the flasks were covered and incubated in a 40°C water bath with agitation for 60 min. The pH was adjusted to 4.5 with HCl; then the solution was filtered through a dry, weighed crucible (P2) containing 0.5 g of dry Celite and washed with 2× 10 ml of distilled water. The residue (water-insoluble dietary fiber) was washed with 2× 10 ml of 94% ethanol and 2× 10 ml of acetone, dried at 105°C overnight, then weighed and ashed at 550°C overnight. For water-soluble dietary fiber, 400 ml of warm 94% ethanol (60°C) was added to the filtrate, and the precipitate was allowed to form for 1 hr. The solution was filtered as before, then washed with 2× 10 ml of 78% and 94% ethanol and 2× 10 ml of acetone. The precipitate

[1]Department of Food Chemistry and Technology, University of Helsinki, SF-00710 Helsinki, Finland. Present address of first author: Dairy Council, Vuorikatu 22 A 11, SF-00100 Helsinki.
[2]Alko Ltd, SF-05200 Rajamäki.

(water-soluble dietary fiber) was dried at 105°C overnight, then weighed and ashed as for the water-insoluble dietary fiber. Blank values were obtained by following the procedure without a sample.

For protein correction, nitrogen content of the dietary fiber fractions and blanks was determined by the Kjeldahl method and converted to protein (× 6.25) (Asp et al 1983). Based on the determination of protein content in fiber residues of 16 varieties, the variation was found to be very small. The standard deviation of the method was greater than that of the protein values. Therefore, constant protein values were used in the calculations.

The water-insoluble (WIS) and water-soluble (WS) dietary fiber contents were calculated using the following equation. The total dietary fiber was the sum of these two values (Asp et al 1983).

$$\%\ \mathrm{WIS\ (WS)} = \frac{D - I - B}{W} \cdot 100 - \frac{\text{protein-\%}}{100} \cdot \frac{D - I - B}{W}$$

Where, D = weight (g) after drying in fiber determination, I = weight (g) after incineration, B = weight (g) of ash-free blank, W = sample weight (g), and protein-% = 9.0 for WIS and 7.5 for WS dietary fiber.

TABLE I
Reproducibility of the Method Tested by 14 Dietary Fiber Determinations Using One Barley Variety

	Dietary Fiber (% of dry matter)		
Parameter	**Water-Insoluble**	**Water-Soluble**	**Total**
Mean	16.4	3.4	19.8
Standard deviation	0.58	0.39	0.59
Variance	0.33	0.16	0.35
Range	14.8–17.2	2.7–4.0	18.5–20.6

TABLE II
Dietary Fiber in Two-Rowed and Six-Rowed Barley Varieties

	Dietary Fiber (% of dry matter)			
Barley (*n*)	**Water-Insoluble**	**Water-Soluble**	**Total**	**WIS/WS[a]**
Two-rowed (68) Mean	15.0 a[b]	4.9 a	19.9 a	3.1 a
SD	1.41	0.50	1.63	0.39
Range	11.1–19.2	3.4–5.9	15.0–23.9	2.4–4.4
Six-rowed (50) Mean	16.6 b	4.3 b	20.9 b	3.9 b
SD	1.17	0.51	1.32	0.50
Range	13.9–19.2	3.3–5.8	17.7–24.1	2.8–4.9

[a]WIS = Water-insoluble dietary fiber, WS = water-soluble dietary fiber.
[b]Different letters following means within a column indicate a significant difference at the 0.05 level of significance.

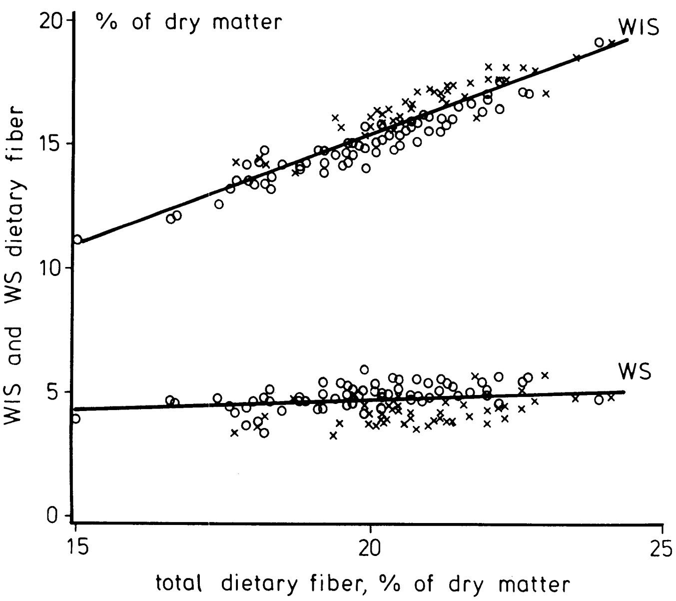

Fig. 1. Water-insoluble (WIS) and water-soluble (WS) dietary fiber in two- (O) and six-rowed (X) barley varieties correlated with total dietary fiber.

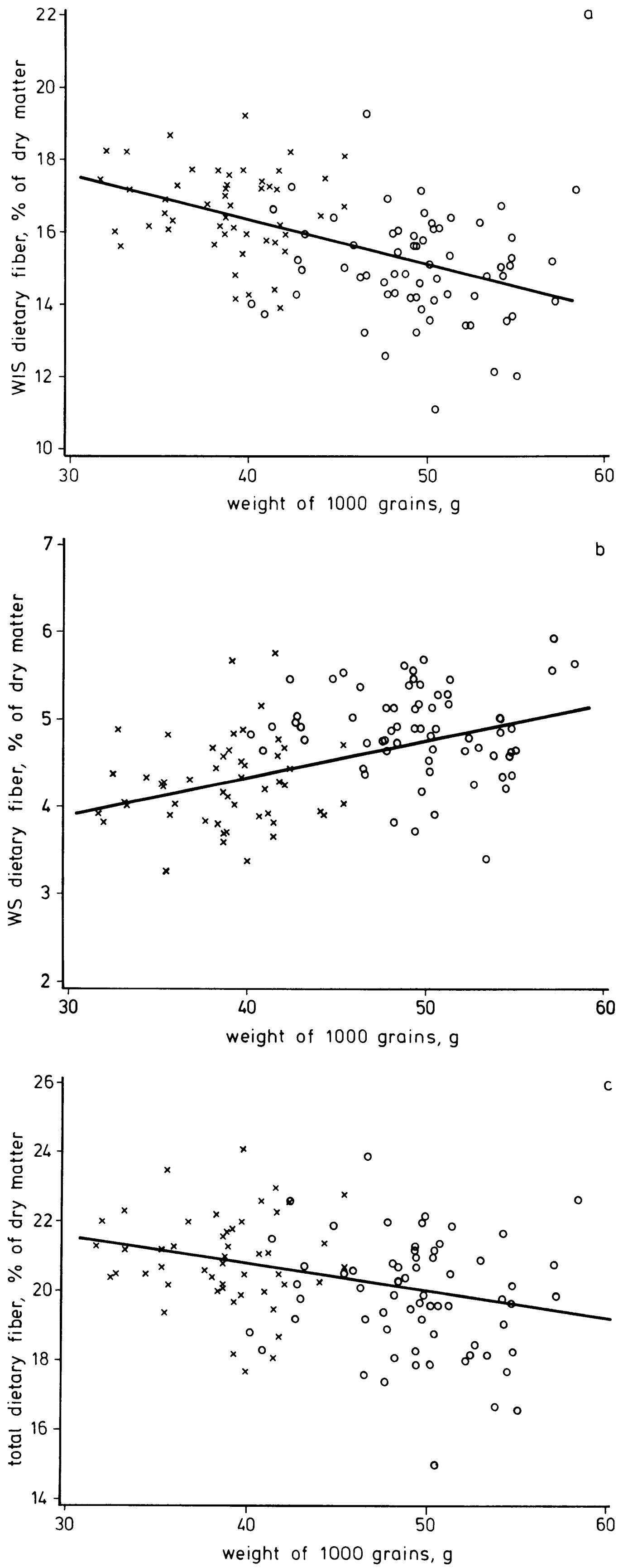

Fig. 2. Relation of the weight of 1,000 grains to the water-insoluble (**A**), water-soluble (**B**), and total dietary fiber (**C**).

TABLE III
Dietary Fiber in Two- and Six-Rowed Barley Grown in Different Locations

Barley/ Farm (n)	Parameter[a]	Dietary Fiber (% of dry matter) Water-Insoluble	Water-Soluble	Total	WIS/WS[b]
Two-rowed					
Anttila (48)	$\bar{x}$	14.8 a[c]	4.8 a	19.6 a	3.1 a
(southern)	SD	1.38	0.54	1.67	0.39
	R	11.1–17.6	3.4–5.9	15.0–22.7	2.4–4.4
Nikkila (20)	$\bar{x}$	15.4 a	5.0 a	20.4 a	3.1 a
(central)	SD	1.43	0.32	1.43	0.40
	R	13.2–19.2	4.5–5.5	18.2–23.9	2.6–4.1
Six-rowed					
Anttila (31)	$\bar{x}$	16.8 a[c]	4.1 a	20.9 a	4.1 a
(southern)	SD	0.93	0.37	1.06	0.40
	R	14.3–18.2	3.3–4.9	17.7–22.8	3.2–4.9
Nikkila (11)	$\bar{x}$	16.7 ab	4.7 b	21.4 a	3.6 a
(central)	SD	1.43	0.66	1.79	0.46
	R	14.4–19.2	3.7–5.8	18.1–24.1	2.8–4.4
Viskaali (8)	$\bar{x}$	15.7 b	4.3 ab	20.0 a	3.6 a
(northern)	SD	1.32	0.42	1.22	0.55
	R	13.9–17.5	3.8–4.8	18.2–21.6	2.9–4.1

[a] $\bar{x}$ = Mean value, SD = standard deviation, R = range.
[b] WIS = Water-insoluble dietary fiber; WS = water-soluble dietary fiber.
[c] Different letters within a column indicate a significant difference at 0.05 level of significance.

Statistical Analyses

The design of the growing experiments did not allow comparisons of the fiber content of different barley lines. The differences between two- and six-rowed barley varieties and the effect of the location of growth were studied statistically. The statistical analyses were done using SAS (1985) software.

RESULTS AND DISCUSSION

The reproducibility of the method of Asp et al (1983), given as a variation of 14 replicate determinations, is presented in Table I.

The values for WIS and WS dietary fiber varied more than those of total dietary fiber. This can be explained by irregular solubilization of the dietary fiber components.

The means of WIS, WS, and total dietary fiber and the WIS/WS ratio of two- and six-rowed barley varieties are presented in Table II. There was more total and WIS dietary fiber and less WS dietary fiber in six-rowed than in two-rowed varieties. The WIS/WS ratio varied. One-fourth of the total dietary fiber in the two-rowed and one-fifth in the six-rowed barley grains were water-soluble. Figure 1 shows the different distributions: the points for WIS dietary fiber of two-rowed varieties lie below the correlation curve and those for WS dietary fiber above it.

As usual, the grains of two-rowed barley ears were bigger than those of six-rowed varieties. There was relatively more WIS dietary fiber-rich husk and less WS dietary fiber-rich endosperm in six-rowed varieties. Figure 2 shows the differences in grain size. The correlation of grain size was inverse to WIS ($r = -0.50$) and directly related to WS dietary fiber ($r = 0.43$).

Using the same method, Nyman et al (1984) obtained values similar to those of the present study for WIS and WS dietary fiber of barley. In other studies, different methods have been used, resulting in dietary fiber yields lower than those observed in this study (Englyst 1981, Salomonsson et al 1984, Varo et al 1984, Åman and Hesselman 1984).

The effect of location is presented in Table III. There was no statistically significant difference between the results for two-rowed barley varieties grown in the southern and central parts of Finland. The total dietary fiber content of the six-rowed varieties was the same in all three locations, but there was more water-insoluble dietary fiber in barleys from southern Finland than in those grown in the north. There were also some differences in water-soluble dietary fiber according to the location. In addition to the effects of the geographic location, however, many other variables such as fertilization, irrigation, harvesting, and storage of the grains may have affected the composition of barley. It was not possible to control these factors in this study.

CONCLUSIONS

Barley grain size was the main determinant of the amount of dietary fiber: the smaller the grain the higher the dietary fiber content and the larger the proportion of water-insoluble dietary fiber. The location of growth did not have a significant effect on the dietary fiber content.

The protein content of the barley indigestible matter was nearly constant. Therefore, a reasonable simplification of the method was obtained by omitting protein determination in the majority of the samples and using constant values for proteins in the water-insoluble and water-soluble dietary fiber calculations.

LITERATURE CITED

ÅMAN, P., and HESSELMAN, K. 1984. Analysis of starch and other main constituents of cereal grains. Swed. J. Agric. Res. 14:135-139.

ASP, N.-G., JOHANSSON, C.-G., HALLMER, H., and SILJESTRÖM, M. 1983. Rapid enzymatic assay of insoluble and soluble dietary fiber. J. Agric. Food Chem. 31:476-482.

BURKITT, D. P., WALKER, A. R. P., and PAINTER, N. S. 1972. Effect of dietary fiber on stools and transit times, and its role in the causation of diseases. Lancet 1972:1408-1411.

ENGLYST, H. 1981. Determination of carbohydrate and its composition in plant materials. Pages 71-93 in: The Analysis of Dietary Fiber in Food. W. P. T. James and O. Theander, eds. Marcel Dekker: New York.

NYMAN, M., SILJESTRÖM, M., PEDERSEN, B., BACH KNUDSEN, K. E., ASP, N.-G., JOHANSSON, C.-G., and EGGUM, B. O. 1984. Dietary fiber content and composition in six cereals at different extraction rates. Cereal Chem. 61:14-19.

PROSKY, L., ASP, N.-G., FURDA, I., DEVRIES, J., SCHWEIZER, T., and HARLAND, B. 1984. Determination of total dietary fiber in foods, food products, and total diets: Interlaboratory study. J. Assoc. Off. Anal. Chem. 67:1044-1052.

SALOMONSSON, A.-C., THEANDER, O., and WESTERLUND, E. 1984. Chemical characterization of some Swedish cereal whole meal and bran fractions. Swed. J. Agric. Res. 14:111-117.

SAS. 1985. User's Guide. Version 5 Edition. SAS Institute Inc.: Cary, NC.

VARO, P., LAINE, R., VEIJALAINEN, K., PERO, K., and KOIVISTOINEN, P. 1984. Dietary fibre and available carbohydrates in Finnish cereal products. J. Sci. Agric. Soc. Finl. 56:39-48.

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