NOTE

β-Glucan in Two- and Six-Rowed Barley

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ABSTRACT

The content of β-glucan in 50 six-rowed and 68 two-rowed barley varieties was measured. The content in two-rowed barley grown in southern Finland varied between 3.5 and 5.3% of dry matter. The range in two-rowed varieties grown in central Finland was 4.0–5.2%. The corresponding ranges in the six-rowed varieties grown in southern, central, and northern Finland were 2.8–4.3, 3.3–5.6, and 3.6–4.0%, respectively. The average results indicated that the two-rowed varieties are somewhat richer in β-glucan than the six-rowed ones. The content of β-glucan in barley varieties was dependent on characteristics of the variety, the ear type, and the conditions during growth.

One of the minor constituents in barley kernels, mixed-linkage (1,3)(1,4)-β-D-glucans (called hereafter β-glucan), is present in soluble and insoluble forms. Most of the β-glucan is located in endosperm cell walls, but aleurone cell walls are also rich in β-glucan. According to Forrest and Wainwright (1977), 75% of the dry matter of endospermic cell walls is β-glucan. The corresponding value in aleurone cell walls is less than 10%. Because β-glucan forms viscous solutions, it can cause problems, for instance in the brewing industry, such as slow beer filtration or haze formation. β-Glucan also reduces the value of barley as a feed (Crabb and Bathgate 1973, Letters 1969).

There exist several methods for the determination of β-glucan from cereals. A method developed by Ahluwalia and Ellis (1984) is based on perchloric acid extraction of β-glucan and starch, followed by enzymatic degradation of β-glucan to glucose with cellulase from *Penicillum funiculosum*. Glucose was determined by the hexokinase/glucose-6-phosphate method. In a similar procedure, Martin and Bamforth (1981) used *Trichoderma reesei* cellulase to hydrolyze β-glucan. McClear and Glennie-Holmes (1985) depolymerized β-glucan with endo-(1,3)(1,4)-β-D-glucan 4-glucanohydrolase (lichenase) to oligosaccharides and hydrolyzed these to glucose with purified β-D-glucosidase; glucose was determined using the glucose oxidase-peroxidase method. The advantage of McClear and Glennie-Holmes's method is the direct hydrolysis of β-glucan without previous separation from barley flour.

The aim of this study was to collect analytical data for the β-glucan content of barley varieties grown in different parts of Finland.

MATERIALS AND METHODS

Samples

The samples represented 50 six-rowed and 68 two-rowed barley varieties and were the same as those used earlier for the determination of pentosans (Lehtonen and Aikasalo 1987). They were grown in southern, central, and northern Finland at farms with the following geographical coordinates: Anttila Experimental Farm, 25.03° E and 60.42° N; Nikkilä Experimental Farm, 24.23° E and 61.55° N; and Viskaali Trial Fields, 25.98° E and 64.82° N.

Barley samples of 3.1 and 4.3% β-glucan (dry matter basis) obtained from Biocon Ltd. were also analyzed according to the method described below.

Sample Pretreatment and Analytical Method

Barley samples were ground with a Tecator Cyclotec 1093 sample mill using a 0.5-mm sieve; an accurately weighed sample (0.5 g) of carefully mixed barley flour was taken for analysis. β-Glucan was measured with the method developed by McClear and Glennie-Holmes (1985), except that glucose was determined using the hexokinase/glucose-6-phosphate dehydrogenase method (Boehringer-Mannheim 1984). The percentage of β-glucan was obtained from the following formula

$$\% \beta\text{-Glucan} = 3{,}886 \times \frac{dA}{W \times (k/100)} \times 100$$

where dA = the difference in absorbance measured before and 10–15 min after the addition of hexokinase and glucose-6-phosphate dehydrogenase; W = weight of sample; and k = percentage of dry matter in the sample. Analyses were made in duplicate.

RESULTS AND DISCUSSION

The method developed by McClear and Glennie-Holmes is quite simple and very suitable for the determination of β-glucan in barley. The method seems to be both quantitative and reproducible, which is shown with 26 independent determinations and the analyses of test samples. The results give a value of 0.25 for standard deviation, 4.8% for coefficient of variation, and 100% recovery.

Table I summarizes the results obtained for the content of β-glucan in the barley varieties. The corresponding mean values with standard deviations and minimum and maximum values are presented in Table II. According to these results, the content of β-glucan varied between 3.5 and 5.3% of the dry matter in the two-rowed varieties grown at Anttila. The corresponding range of values for two-rowed varieties grown at Nikkilä was 4.0–5.2%. The six-rowed varieties grown at Anttila contained 2.8–4.3% β-glucan, whereas the six-rowed varieties grown at Nikkilä and Viskaali contained between 3.3–5.6% and 3.6–4.0%, respectively.

Gill et al (1982) and Bamforth (1983) also studied the content of β-glucan in different barley varieties. Some of those varieties are also included in our studies, and the results are in good agreement with those previously reported. The results obtained by Bendelow (1975), Ahluwalia and Ellis (1984), and Åhman and Hesselman (1985) are also similar. Prentice and co-workers (1980) obtained somewhat higher results.

The results indicate that the content of β-glucan is significantly higher in two-rowed varieties than in the six-rowed ones. This conclusion is valid between varieties grown at Anttila (student's t value 7.83) and at Nikkilä (student's t value 2.59).

To determine the effect of different locations on the β-glucan content, we examined the results for those varieties grown at all three farms. The results suggest that β-glucan content depends strongly on where the barley was grown and also on the characteristics of the barley variety (Table III). The two-way

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TABLE I
β-Glucan Content (%) of Six- and Two-Rowed Barley Varieties Grown at Different Sites

Variety Type	Anttila (%)				Nikkilä (%)		Viskaali (%)	
Six-rowed	Otra	3.8	Hja 77061	3.5	Agneta	3.8	Agneta	3.6
	Pirkka	3.5	Hja 78003	3.1	Arra	4.5	Arra	3.8
	Hja-673	3.8	Hja 78042	3.8	Hja-673	4.2	Hjan Eero	4.0
	Hjan Eero	3.5	Hja 63909	4.0	Hjan Pokko	3.9	Hjan Pokko	3.6
	Hjan Pokko	3.4	Hja 63912	3.8	Kalle	3.5	Hja-673	3.9
	Hjan Potra	4.2	Hja 78104	3.1	Pomo	3.3	Ibon 258	3.9
	Pomo	4.1	Hja 79671	4.2	Sch. 1638.73	4.4	Manker	3.9
	Silja	3.7	Hja 79678	3.3	Tunga	4.5	Pomo	3.7
	Kilta	4.3	Hja 78012	3.5	Vena	5.0	...	...
	Arra	4.1	Hja 77082	4.1	Yrjar	4.4	...	...
	Paavo	3.5	SVJ 7229	3.0	Lise	5.6	...	...
	Kajsa	3.2	Jo 1360	3.7	...	...	...	...
	Agneta	2.8	Jo 1374	4.0	...	...	...	...
	Kalle	3.4	Jo 1328	3.3	...	...	...	...
	Hja 71384	3.9	Pomo	3.8	...	...	...	...
	Hja 70185	3.7	...	...	...	...	...	...
Two-rowed	Ida	4.8	Grit	4.0	Atem	5.1	...	...
	Karri	4.1	Cerise	4.3	Europa	4.7	...	...
	SvÅ 72112	5.0	Roland	4.9	Gunhild	4.5	...	...
	WW 6731	4.3	RPB 822.77	5.3	Hjan Aapo	4.4	...	...
	Hja 62403	4.1	Karat	3.9	Ida	4.7	...	...
	Hja 62434	4.3	RPB 412.78	3.8	Ideal	4.7	...	...
	Hja 62418	4.0	Trumpf	3.9	Ingrid	4.9	...	...
	Hja 62599	4.0	Diabas	4.0	Kustaa	4.5	...	...
	Hja 62845	4.3	Koru	4.8	MG 4074.5	5.2	...	...
	Hja 78036	4.6	Koral	4.1	MG 7168	4.6	...	...
	Hja 78175	4.4	Hja 62485	4.9	M 1162	4.8	...	...
	Hja 77059	4.0	Zephyr	4.2	RPB 1036.78	4.8	...	...
	Hja 62721	4.5	Safir	3.9	RPB 7506.20-1	5.2	...	...
	Havila	4.5	Gimpel	4.0	Semu 1271	5.0	...	...
	Kym	4.4	Opal	5.0	Semu 2269	4.4	...	...
	Patty	4.4	Maris Mink	5.1	Semu 2280	4.0	...	...
	Jo 1369	4.3	Spartan	4.3	Semu 0242	4.9	...	...
	Jo 1220	4.1	RPB 459.78	4.6	Semu 1166	4.7	...	...
	Hjan Aapo	4.6	RPB 9002.77	4.1	Stange	4.9	...	...
	Ingrid	4.1	Apex	4.6	Tron	4.5	...	...
	Kustaa	4.0	Tasman	3.5	...	...	...	...
	Hjan Aapo	4.7	Aladin	4.4	...	...	...	...
	Ida	4.9	Yriba	4.3	...	...	...	...
	Flare	5.0	Cytris	4.0	...	...	...	...

TABLE II
Average Values, Standard Deviations, and Minimum and Maximum Values Obtained for the β-Glucan Contents of Barley Varieties Grown at Different Locations

Farm	Anttila		Nikkilä		Viskaali
Variety	Two-Rowed	Six-Rowed	Two-Rowed	Six-Rowed	Six-Rowed
n	48	31	20	11	8
Mean	4.36 a[a]	3.65 b	4.72 c	4.28 a	3.80 b
SD	0.40	0.39	0.30	0.66	0.15
Min	3.5	2.8	4.0	3.3	3.6
Max	5.3	4.3	5.2	5.6	4.0

[a] Different letters indicate significant differences at a 5% level.

TABLE III
Two-Way Variance Table of β-Glucan Contents of Varieties Grown at Different Locations

Source	Degrees of Freedom	Sum of Squares	*F* Value
Variety	4	2.17	31.97*[a]
Location	2	0.47	13.92*
Variety × location	8	2.02	14.91*
Error	18	0.30	
Total	32	4.97	

[a] * Significant at the 5% level.

variance table indicates a very significant interaction between location and variety. The effect of location is likely to result from different fertilization and climatic conditions as well as from the latitude. Bourne and Pierce (1972) reported similar environmental effects on the β-glucan contents of barley.

CONCLUSION

Results obtained show that the content of β-glucan is somewhat higher in two-rowed varieties than in six-rowed ones. It is evident that in addition to variety, the content of β-glucan is also dependent on ear type. Also, the amount of β-glucan in barley kernels appears to depend on environmental conditions during growth.

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