NOTE

β-Glucan and Flour Yield of Hull-less Barley

R. S. Bhatty[1]

Cereal Chem. 76(2):314–315

In a previous study on the milling of hull-less barley (HB) for the production of bran and flour, it was reported that waxy (low amylose) HB cultivars gave lower flour yields than normal starch HB (59 vs. 42%) milled on as-is moisture basis in a Buhler mill (Bhatty 1997). Two cultivars of HB containing normal or waxy starch had similar grind times, a measure of grain hardness, but significantly different β-glucan and flour yields. This suggested that β-glucan may be responsible for lower flour yield of the waxy cultivars. To test this hypothesis further, 10 HB genotypes and cultivars containing low or high β-glucan were milled under identical conditions and their flour yields compared.

Registered HB cultivars (AC Hawkeye, CDC Buck, CDC Candle, CDC Dawn, CDC Richard, Falcon, Merlin) and three HB genotypes (SB90354, SB94794, 92-55-08-31) were obtained from B. Rossnagel of the Crop Development Centre, University of Saskatchewan. CDC Candle, CDC Dawn, CDC Richard, Merlin, SB90354, SB94794, and 92-55-08-31 were two-rowed and AC Hawkeye, CDC Buck, and Falcon were six-rowed; they were grown in 1996 at the Kernen Crop Research Farm, University of Saskatchewan. The HB were arbitrarily classified having low or high β-glucan (Table I). The low β-glucan HB (4–5%) were all normal starch cultivars, whereas the high β-glucan group (6–8%) had waxy or low amylose (0–5%) starch, except line 92-55-08-31 which had high amylose (37%) starch.

The 10 cultivars were dry-milled in a Buhler mill (MLU 202) as described previously (Bhatty 1997). Two high β-glucan cultivars (CDC Candle and Merlin) and two low β-glucan cultivars (CDC Dawn and CDC Richard) were also milled in an Allis-Chalmers experimental mill. Break and reduction flours were combined in each case to obtain total flour yield or extraction rate, which was calculated by dividing the weight of flour by the weight of grain × 100 (db).

For chemical analysis, the barleys were ground in a Udy cyclone mill to pass a 0.5-mm screen. Kernel weight was determined by weighing 200 seeds. Ash and protein (N × 6.25) were determined by Approved Methods 08-03 and 46-13, respectively (AACC 1995). Starch was determined using the method of Holm et al (1986) after boiling samples with 80% ethanol and centrifuging at 2000 × *g* for 10 min. β-Glucan was determined using the Megazyme kit based on the method of McCleary and Glennie-Holmes (1985). Particle-size distribution of flour samples was measured by shaking 100 g of flour for 5 min in a sieve shaker (Ro-tap), using screens 105–300 µm. Particle size of each fraction was expressed as percent of the total.

Composition and Flour Yields

Grain composition, other than β-glucan, of the HB was not significantly different (Table I). The high β-glucan group contained, on average, 50% more β-glucan than the low β-glucan group. There was a significant negative correlation ($r = 0.73$) between protein and starch when the data from the two groups were combined. The high β-glucan HB were heavier than the low β-glucan HB. The major difference ($P < 0.01$) observed between the high and low β-glucan HB was in flour yields. The mean flour yield was 60% in the low β-glucan HB and only 43% in the high β-glucan HB, almost identical to data reported previously (Bhatty 1997) for two normal (low β-glucan) or waxy starch (high β-glucan) HB cultivars. Sundberg and Åman (1994) also reported lower flour yield in waxy HB as compared to regular starch barley (51 vs. 67%) milled in a Buhler mill but gave no explanation for the yield differences in the two types of barley. The range obtained in flour yields was higher in the high β-glucan HB (38–52%) compared to 57–64% in the low β-glucan HB (Table I). There was a highly significant negative correlation ($r = 0.92$) between β-glucan level and flour yield (Fig. 1).

The mean flour yield ($n = 5$) in low β-glucan HB was 38% higher than in high β-glucan cultivars, essentially due to better separation of bran and flour. Particle-size distribution in the low or high β-glucan HB flour samples is shown in Fig. 2A. Clearly, the high β-glucan HB flour had a higher proportion of particles in the 150–250 µm range, which constituted 62% of the total flour. Particles <105–150 µm formed 27% of high β-glucan HB flour. In low β-glucan HB flour, the proportion of flour in the same particle ranges was reversed. The 150–250 µm range contained 38% of the flour and the <105–150 µm range contained 54% of the flour. Roller gaps in the Buhler laboratory mill were adjusted to 0.04 mm. The reduction flour could not be manually returned for regrinding and sifting to obtain the desired flour yield (≈70%). Consequently, the larger flour particles of high β-glucan HB appeared in the bran fractions, thereby reducing flour yields. The milling yields of high β-glucan HB obtained in this and the previous study (Bhatty 1997) suggested that β-glucan, largely present in the endosperm cell walls, resists particle-size reduction during the milling process, which leads to lower flour yields. The mechanism of this resistance needs further investigation.

Table II shows chemical composition of the two particle-size fractions obtained on milling five low or high β-glucan HB cultivars. The paired *t*-test was significant for starch and protein but not for β-glucan in the 105–150 µm fraction. In the 150–250 µm fraction, the major flour fraction, no significant differences were observed for protein or β-glucan. Only the starch difference was significant; the mean of high β-glucan HB cultivars was lower than those of the low β-glucan cultivars. Thus, there seemed to be no shift in β-glucan of low or high β-glucan milled particle-size fractions.

For further comparison of flour yields, two low (CDC Dawn and CDC Richard) or two high (CDC Candle and Merlin) β-glucan HB were milled in an Allis-Chalmers experimental mill. The roller gaps for reduction rolls were adjusted to a width similar to that in the Buhler laboratory mill (0.04 mm). Reduction flour was manually returned to reduction rolls until the desired flour yield was obtained. In th Allis-Chalmers mill, it was possible to mill high or low β-glucan HB to nearly similar flour yields (71 vs. 69%), although it took longer to mill high β-glucan HB. particle-size distribution in Allis-Chalmers milled low or high β-glucan flours (Fig 2B) was nearly similar, in contrast to those milled in the Buhler mill (Fig. 2A).

The results of the milling studies showed that high β-glucan HB (usually waxy cultivars) gave lower flour yields than low β-glucan HB, milled under identical conditions. This seemed due to a high proportion of large particles in the high β-glucan HB flour that appeared in the bran fraction. It is possible that some large particles had flour adhering to the bran. Such flour may be regained by using a bran finisher. However, the flour samples were vigorously

[1] Crop Development Centre, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK S7N 5A8. Phone: 306/966-4970. Fax: 306/966-5015. E-mail: bhattyrs@duke.usask.ca

Publication no. C-1999-0218-02R.

TABLE I
Grain Composition and Flour Yields (%) of Five Low or High β-Glucan Hull-less Barleys Used in the Milling Study

	TKW[a] (g)	Yield	Ash	Protein	Starch	β-Glucan
Low β-glucan						
AC Hawkeye	43.7	63.6	1.5	13.0	67.6	4.6
CDC Buck	42.7	58.6	1.5	12.8	68.6	5.0
CDC Dawn	42.4	59.6	1.8	12.8	74.5	4.6
CDC Richard	47.6	58.4	2.1	13.3	69.3	4.1
Falcon	38.6	57.1	2.3	15.7	59.1	4.6
Mean	43.0	59.6	1.8	13.5	67.8	4.8
High β-glucan						
CDC Candle	44.3	38.4	2.1	15.6	62.0	7.3
Merlin	50.5	45.1	1.9	16.8	60.1	6.4
SB90354	53.8	51.9	2.0	15.1	64.7	6.5
SB94794	52.9	39.9	2.1	15.0	63.6	7.3
92-55-08-31	57.3	40.7	2.3	13.8	58.0	8.3
Mean	51.8	43.2	2.1	15.3	61.7	7.2
LSD[b]	1.2	4.0	0.1	0.4	2.3	0.3
t-test[c]	*	**	ns	ns	ns	*

[a] 1,000 kernel weight.
[b] Least significant difference ($P < 0.05$).
[c] **$P < 0.01$, * $P < 0.05$, ns = not significant.

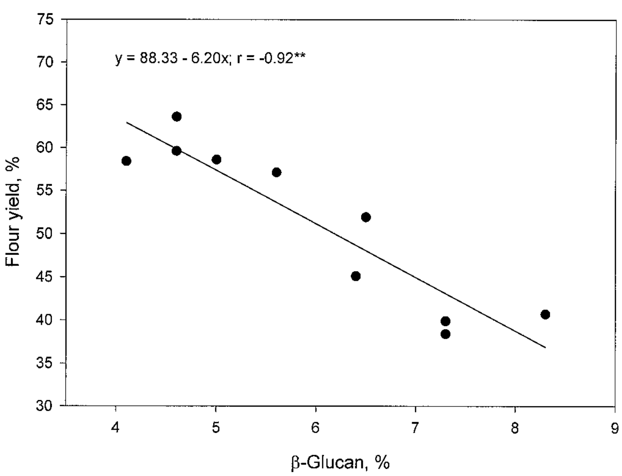

Fig. 1. Correlation between β-glucan content and flour yield in 10 samples of hull-less barley dry-milled (as-is moisture) in a Buhler mill.

shaken during particle-size determination which was likely to loosen adhering flour, if any. Waxy HB generally, though not always, have high β-glucan. Milling waxy HB will require milling process optimization, and possibly a longer milling time.

ACKNOWLEDGMENTS

This study was part of the milling project on hull-less barley funded by the Alberta barley Commission. B. Rossnagel again generously provided the hull-less barley samples and L. Jackson excellent technical assistance

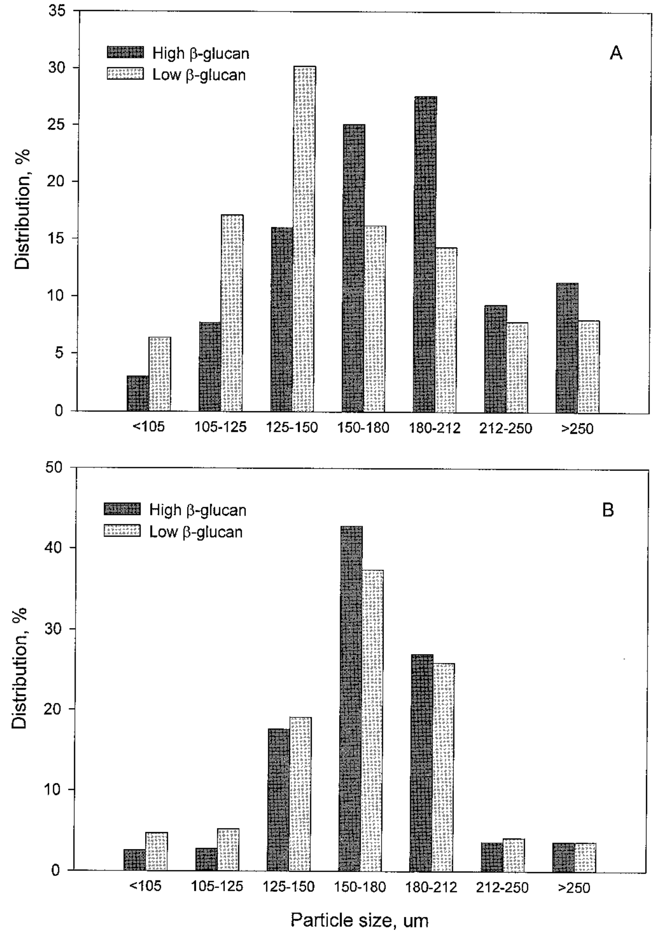

Fig. 2. Mean (n = 5) particle-size distribution in high or low β-glucan hull-less barley (HB) flours milled in a Buhler mill (**A**) and in an Allis-Chalmers experimental mill (**B**).

TABLE II
Composition of Particle-Size Fractions (%) of Low and High β-Glucan Hull-less Barleys Milled in a Buhler Mill

	105–150 µm			150–250 µm		
Cultivar	Starch	Protein	β-Glucan	Starch	Protein	β-Glucan
Low β-glucan						
AC Hawkeye	87.5	9.9	2.4	75.4	13.0	5.6
CDC Buck	87.6	10.0	2.5	70.7	13.6	6.7
CDC Dawn	86.4	10.1	2.5	73.4	12.6	6.6
CDC Richard	82.7	11.3	2.3	67.4	14.1	6.3
Falcon	92.4	11.0	2.4	73.0	15.6	6.1
Mean[a]	87.3	10.5	2.4	72.0	13.8	6.3
High β-glucan						
CDC Candle	79.5	14.2	2.4	62.6	17.4	5.8
Merlin	78.7	14.5	2.5	52.6	19.6	6.8
SB90354	75.9	13.5	3.4	66.2	13.6	7.2
SB94794	76.8	14.5	2.5	68.1	15.6	4.9
92-55-08-31	71.2	15.8	2.9	61.6	15.3	5.3
Mean[a]	76.4	14.5	2.7	62.2	16.3	6.0
t-test[b]	**	**	ns	*	ns	ns

[a] Mean of hull-less barley cultivars (n = 5 in each group) listed in Table I.
[b] ** $P < 0.01$, * $P < 0.05$, ns = not significant.

LITERATURE CITED

American Association of Cereal Chemists. 1995. Approved Methods of the AACC, 9th ed. Method 08-03, approved April 1961, revised October 1976 and October 1981, reviewed October 1994; Method 46-13, approved October 1976, revised October 1986, reviewed October 1994. The Association: St. Paul, MN.

Bhatty, R. S. 1997. Milling of regular and waxy starch barleys for the production of bran and flour. Cereal Chem. 74:693-699.

Bhatty, R. S. 1987. Milling yield and flour quality of hull-less barley. Cereal Foods World 32:268-272.

Holm, J., Bjorek, F., Draws, A., and Asp, N. G. 1986. A rapid method for the analysis of starch. Starch/Staerke 38:224-227.

McCleary, B. V., and Glennie-Holmes, M. 1985. Enzymatic quantification of (1→3),(1→4)-β-D-glucan in barley and malt. J. Inst. Brew. 91:285-295.

Sundberg, B., and Åman, P. 1994. Fractionation of different types of barley by roller-milling. J. Cereal Sci. 19:179-184.

[Received May 27, 1998. Accepted November 3, 1998.]