Physiochemical and Functional (Breadmaking) Properties of Hull-less Barley Fractions

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ABSTRACT

Cereal Chem. 63(1):31–35

Two cultivars of hull-less barley, Scout (two-rowed) and Tupper (six-rowed) were ground to a meal, milled to 70–74% flour yield, fine-pearled, and the pearled grain was ground into meal. The three fractions from each cultivar, meal, flour, and pearled meal, were used to study physiochemical and functional (breadmaking) properties. The fractions contained 13.3–18.9% protein (N × 6.25), 1.1–2.1% ash and lipids, and 0.8–1.6% fiber; palmitic (16:0), oleic (18:1), and linoleic (18:2) were the major fatty acids. The flour and pearled meal fractions, particularly of Tupper barley, were as white as commercial wheat flour. Particle size distribution showed barley flours contained about 25% large particles (> 150 μm), whereas wheat flour contained about 6%. A major portion of barley flour particles (44.5%) fell in the 38–44 μm range. The flour particles had a protruding matrix with mostly small starch granules embedded in it. The pearled meal of Scout had higher water hydration capacity, alkaline-water retention capacity, and fat absorption than did Tupper pearled meal. Barley flour had similar pasting temperature (64–66° C) to wheat flour but lower peak viscosity. The pearled meals had high Brabender peak (775–1,060 BU) and setback (755–1,300 BU) viscosities. Mixogram data and bread baked from composite flour samples suggested that 5% or possibly 10% barley flour could be added to wheat flour without seriously affecting loaf volume and bread appearance.

Hull-less (or naked) barley has potential for use in food products. Unlike hulled or covered barley, which is highly fibrous, hull-less barley has the same level of fiber as wheat and corn. It can be directly ground to a meal, milled to flour, pearled, or used for the preparation of food malt. A number of studies have been published on the suitability of hull-less barley for malting (Ballesteros and Piendl 1977, Rennecke and Sommer 1979, Singh and Sosulski 1985). Some barley products may be used in muffins, biscuits, flat unleavened bread (chapati), and flour snacks.

Although hulled barley is a major cereal crop in western countries, most is used for animal feed, some for malt, and very little for food. The average consumption of hulled barley in Canada is 85% for animal feed, 10% for malt, and 5% for food (Rossnagel et al 1982). Annual per capita consumption of hulled barley as food (other than malt) in the United States was only 0.5 kg compared to 50 kg of wheat, 3.5 kg of rice, and 0.5 kg of rye (Pomeranz 1973). At the turn of the century, barley was a major dietary source in Denmark (Munck 1981), where it has been replaced by wheat. In Korea, where most barley is used as pearled barley, barley consumption dropped from 40.3 kg to 18 kg per person a year between 1974 and 1978 (Cheigh 1979). The low consumption of barley undoubtedly is due to increasing use of baked products for which wheat is more suitable than barley, to poor appearance and organoleptic properties of cooked barley products, and to a hull that precludes use of barley in food products until it is first dehulled. However, cultivars of hull-less barley yielding 88% of hulled barley are now available (Rossnagel et al 1983, 1985). These may partially overcome resistance to use of barley in food products.

A number of reports have been published on the superiority of hull-less barley for monogastric and poultry feeds (Bhatty et al 1974, 1975, 1979, 1981; Classen et al 1985a,b). However, few data have been published on the utilization of hull-less barley in food products. The present report describes some of the physiochemical and functional (breadmaking) properties of hull-less barley fractions for their possible use in food products and use of hull-less barley flour in breadmaking.

MATERIALS AND METHODS

Materials

Two cultivars of hull-less barley, Scout (two-rowed) and Tupper (six-rowed), were obtained from stock of grain grown locally at the University of Saskatchewan experimental plots in 1983. Cultivar Tupper contained about 3% and Scout less than 1% by weight hulled seeds. The barley was ground to a meal in a Udy Cyclotec mill having a 1.0-mm screen. Three hundred grams of each cultivar were tempered for 18–24 hr to appropriate moisture levels (Table I) and milled in an Allis-Chalmers experimental mill using a short flow procedure that had three break (roll spacing for [first break] 1B, 0.457 mm; 2B, 0.178 mm; 3B, 0.076 mm), three reduction (roll spacing [first reduction] 1R, 0.064 mm; 2R and 3R, 0.038 mm), and five sifting steps, each 5-min long (first sifting was omitted). Five fractions were obtained: the bran, shorts, break flour, reduction flour, and clear flour. The bran fraction was retained on 20 W screen and the shorts fraction on 70 GG (240 μm) screen. The fraction that passed through 10XX (136 μm) in 2B and 3B was break flour, and the one that passed through the same screen size in 1R, 2R, and 3R was reduction flour. The fraction retained on 10XX in 3R was the clear flour. The break, reduction, and clear flour fractions were combined to obtain total flour yield (flour), which was used in all subsequent studies.

Particle size distribution in barley and wheat flour samples was determined with an Allen-Bradley sonic sifter. Flour sample was 5.0 g and sifting time 15 min. Hardness of Scout hull-less barley and one sample of wheat was determined with the Brabender micro-hardness tester. Barley was pearled for 10 min to 70–72% grain yield in a tangential abrasive dehulling machine (stone A-36), the pearled grain ground to a meal in the Udy Cyclotec mill with 0.5-mm screen. The meal, flour, and pearled meal (hereafter called fractions) obtained from each cultivar were subsequently used for chemical analysis and determination of functional properties.

Color of the fractions was measured with Hunterlab and Agtron colorimeters. In the latter method dry fractions were used, and the Agtron was standardized with nos. 63 (0%) and 97 (100%) disks (AACC 1969). Protein (N × 6.25), ash, fiber, and total lipid contents were determined by the AOAC official procedures (1980). Methyl esters were prepared from total lipids, and fatty acid composition was determined by the method of Welch (1977) with the following exceptions: glass column 6'× ⅛" i.d. packed with GP 3% SP-2310/2% SP-2300 on 100/120 chromosorb WAW obtained from Supelco Inc., Bellefonte, PA; temperatures, oven 190° C, injection port and detector 250° C; peak integration, Hewlett-Packard 3385 A automation system. The carrier gas flow rate was adjusted to complete elution in about 12 min. Each fatty acid was expressed as percent of the total fatty acids.

Water hydration capacity was determined by the procedure of Paton (1981), alkaline water retention capacity (AWRC) by the procedure of Yamazaki et al (1968), and fat absorption as follows: 4 g of each fraction was mixed thoroughly with 25 ml of commercial corn oil (Mazola). The mixture was allowed to stand at room

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temperature for 30 min and then centrifuged at 1890 × g for 25 min. The free oil (supernatant fraction) was measured and percent oil absorption calculated.

Pasting properties of the fractions and a sample of wheat flour were determined with a Brabender Viscoamylograph (700 cm-g sensitivity cartridge) on a 10% (dry weight) slurry adjusted to pH 5.5 with dilute hydrochloric acid. The heating and cooling rates were 1.5° C/min. Pasting temperature, peak viscosity, viscosity at the end of 30-min holding period, and viscosity after cooling to 50° C were determined.

Composite flours were prepared by adding 5, 10, 15, 20, 25, and 50% barley flour (Scout) to commercial untreated wheat flour, and bread baking quality was determined using the AACC straight-dough method (AACC 1969). The standard baking formula contained in addition 15 ppm potassium bromate and 0.5% sodium stearyl 2-lactylate (SSL). Water absorption was about 61% in each case. Loaf volume of baked bread was determined by rapeseed displacement, and the bread was scored for shape, crust color, crumb color, and texture. Dough properties of the composite flours were determined at 65% absorption with a Swenson mixograph. The mixogram curve was measured for time to reach maximum height (dough development time), peak height, and curve area.

Scanning electron microscopy of wheat and barley flour (Scout) was performed by sprinkling powders on taped aluminum stubs which were then coated under vacuum with a gold palladium alloy and scanned with a Cambridge Stereoscan MKII SEM operated at 10 kV.

Until otherwise stated, all data are means of at least duplicate determinations. Standard error of the mean is given for each value in Tables I to VI.

RESULTS AND DISCUSSION

Table I shows that hull-less barley could be milled to obtain 70 to 74% flour yield at a tempering moisture of 11 to 13%. The flour yield was similar when 2 kg of the grain were milled. The flour yield obtained from hull-less barley was comparable to that normally obtained from milling of hard red spring and soft wheats grown under our conditions. Nevertheless, milling of hull-less barley is not without problems. The flour tends to be sticky (less free flowing than wheat flour) and may not always easily separate from the bran and short fractions. This is indicated by low bran yields in Table I. Barley is a soft grain more like cookie and pastry wheats. This was shown by the hardness test. The grinding time for Scout barley was 136 sec compared to 26 sec for Glenlea, a hard utility wheat. Thus, hull-less barley may be milled under conditions normally employed for soft wheat milling. Dry milling or milling after short tempering has been reported to give higher flour yields (Reddick 1979). However, Table I shows that both these procedures gave slightly lower flour yields than was obtained at the optimum tempering. Under conditions of short tempering and dry milling, almost all of the bran appeared in the shorts fraction. A longer tempering time and tempering moisture level of 11–13% as in the present study gave higher flour yields and was therefore the preferred procedure.

Scout and Tupper barley flours contained about 25% large particles (>150 μm) whereas wheat flour contained about 6% (Table II). The larger barley flour particles were probably hull fragments. A major portion of barley flour particles (44.5%) fell in the 38–44 μm range compared to 12.9% for wheat flour, which had a major fraction (71.6%) in the 44–150 μm range. Thus, barley flour had relatively greater percentage composition (by weight) of smaller particles than wheat flour. Smaller particles may influence water absorption and other functional properties of barley flour due to their larger surface area. Scanning electron microscopy (Fig. 1) showed barley flour matrix protruding, ridge-like and, containing mostly small starch granules. This matrix was in contrast to that of wheat flour, which was dense, honeycombed, and contained starch granules of various sizes.

Scout and Tupper barley were pearled to about 72% grain yield in 10 min. The 200-kernel weight of the pearled grain ranged from 3.4 to 4.2 g, indicating fine pearling. On boiling in water or dilute alkaline solution, the kernel crease became prominent and was relatively less white compared to the surrounding endosperm tissue. No distinction could be made between the pearled grain of the two cultivars or pearled grain of Abee, a six-rowed hulled barley pearled in the same way as Scout and Tupper. A deep crease is an undesirable feature of pearled barley as it may become a repository for extraneous matter. It may also contain melanin-like

TABLE I
Milling Yield (%) of Scout and Tupper Hull-less Barleys Tempered to Various Moisture Levels

Tempering Moisture (%)	Scout		Flour				Tupper		Flour			
	Bran	Shorts	Break	Reduction	Clear	Total	Bran	Shorts	Break	Reduction	Clear	Total
11	0.2±0.0	26.7±0.7	29.1±0.7	36.5±0.1	7.6±0.1	73.1±0.7	0.3±0.1	27.6±0.6	33.1±0.8	32.5±0.3	7.2±0.2	72.2±0.7
12	0.2±0.0	27.6±0.6	32.2±0.5	32.4±1.0	7.5±0.1	72.1±0.6	1.0±0.4	26.1±0.2	32.6±0.9	34.1±0.2	6.3±0.1	73.0±0.6
13	0.4±0.0	30.2±0.2	32.0±0.1	29.7±0.4	7.8±0.2	69.4±0.2	1.1±0.4	25.4±0.2	33.8±1.8	33.5±1.7	6.5±0.1	73.6±0.2
14	0.7±0.2	30.8±0.6	32.8±1.3	28.4±1.0	7.4±0.5	68.6±0.8	1.3±0.1	28.2±0.6	35.8±0.2	28.7±0.8	6.3±0.1	70.7±0.7
Short tempering[a]	0.4±0.0	32.8±0.3	27.7±1.0	31.0±1.3	8.2±0.6	66.9±0.3	1.0±0.1	29.0±0.3	31.9±0.7	31.8±0.4	6.4±0.1	70.0±0.4
Dry milling[b]	0.1±0.0	29.7±0.1	28.6±0.5	33.2±0.6	8.4±0.2	70.2±0.1	0.1±0.0	28.8±0.1	30.8±1.0	31.9±0.7	8.5±0.3	71.1±0.1

[a] Tempering time 1 hr; tempering moisture Sout 12%; Tupper 13%.

[b] Grain moisture: Scout 9.9%, Tupper 9.5%.

TABLE II
Relative Particle Size Distribution (%) in Scout and Tupper Hull-less Barleys and Neepawa Wheat Flours Determined with an Allen-Bradley Sonic Sifter

Screen Size (μm)	Scout	Tupper	Neepawa (wheat)[a]
>425	7.2±0.2	6.8±0.4	0.4±0.0
250	8.9±0.3	7.2±0.1	1.0±0.2
150	10.3±0.0	11.3±0.2	4.8±0.2
44	23.5±0.2	26.1±0.4	71.6±0.5
38	44.7±0.4	44.4±0.2	12.9±0.2
<38	5.6±0.5	4.4±0.6	9.4±0.5

[a] Hard red spring wheat tempered to 13% moisture and milled to 76.5% flour yield in an Allis-Chalmers experimental mill.

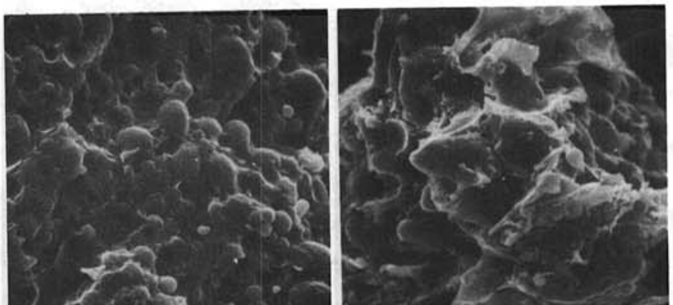

Fig. 1. Scanning-electron microscope micrographs of Neepawa wheat flour (left) and Scout hull-less barley flour (right). Magnification: wheat flour 600, barley flour 654.

pigments that give the grain a darker color on cooking. Barley cultivars having low crease and white aleurone rather than a yellow or blue aleurone are preferred for pearling.

Color values of the three barley fractions and a wheat flour are given in Table III. The Hunterlab *L* values showed, as expected, barley meal to be darker than wheat flour. The flour and pearled meal fractions were white like the wheat flour. The darker color of the meal was most likely due to bran, which may contain melanin-like pigments. The barley fractions contained negligible green pigments (−*a* values) but some yellow pigments (+*b* values). Both Scout and Tupper are yellow aleurone cultivars (Rossnagel et al 1983, 1985). Removal of the aleurone layer with the bran during milling and pearling of barley reduced the levels of these pigments (carotenoids and xanthophylls) in the flour and pearled meal fractions. There was no trace of red (+*a* value) in any of the fractions, including meal. Barley caryopsis usually contains anthocyanins, which appear red in the pericarp and blue in the aleurone (Pomeranz 1973).

The Agtron measures, at 546 nm, color reflectance in flour caused by pigments other than carotenoids (AACC 1969). The Agtron color values are negatively correlated with bran content (Paton and Dinshaw 1968). The higher the Agtron values, the whiter the flour. Table III shows that barley flour, particularly of Tupper, and pearled barley meal were whiter than the wheat flour. As found with the Hunterlab color difference meter, Scout flour was darker than Tupper flour. The meals were much darker than the flour fractions. The standard wheat flour has an Agtron color value of 56 to 60 measured from a flour-water paste (Schiller 1984). Thus, color measurements suggest that barley flour or pearled barley meal may be added to wheat flour without affecting its color quality although they may be bleached under certain conditions. The barley meal is less suitable as an ingredient and needs to be sieved to remove bran.

Table IV gives the proximate and fatty acid composition of the fractions. Barley meals contained 18.9%, flour 16.0–17.1%, and

TABLE III

Color of Wheat Flour and Hull-less Barley Fractions Determined with Hunterlab and Agtron Colorimeters

Fraction	Hunterlab[a] *L*	Hunterlab[a] *a*	Hunterlab[a] *b*	Agtron 546 nm (green)
Wheat flour[b]	+91.0±0.0	−0.9±0.0	+10.3±0.1	60.0±0.0
Meal				
Scout	+85.5±0.1	−0.1±0.0	+11.9±0.1	41.5±0.5
Tupper	+86.3±0.1	−0.1±0.0	+10.4±0.1	44.5±0.5
Flour				
Scout	+88.8±0.2	−0.6±0.0	+ 8.6±0.2	47.7±0.2
Tupper	+90.7±0.1	−0.6±0.1	+ 9.2±0.3	60.7±0.2
Pearled meal				
Scout	+91.6±0.6	−0.4±0.0	+ 6.6±0.1	62.0±0.0
Tupper	+91.8±0.3	−0.7±0.0	+ 8.7±0.3	63.0±0.0

[a] *L* (100 white, 0 black); *a* (+ red, − green); *b* (+ yellow, − blue).

[b] Hard red spring Neepawa wheat milled to 76.5% flour yield.

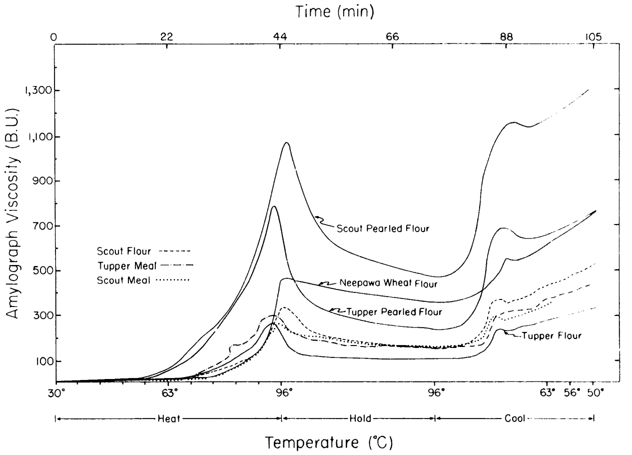

Fig. 2. Viscoamylograms of meal, flour, and pearled meal fractions of Scout and Tupper hull-less barleys and of Neepawa wheat flour.

TABLE IV

Proximate and Fatty Acid Composition (%) of Scout and Tupper Hull-less Barley Fractions (dry basis)

Component	Scout Meal	Scout Flour	Scout Pearled Meal	Tupper Meal	Tupper Flour	Tupper Pearled Meal
Protein (N × 6.25)	18.9±0.1	17.1±0.2	14.7±0.0	18.9±0.0	16.0±0.2	16.1±0.0
Ash	2.0±0.0	1.4±0.0	1.2±0.0	1.7±0.0	1.1±0.0	1.2±0.0
Fiber	1.6±0.0	1.2±0.1	0.9±0.1	1.7±0.1	1.0±0.1	0.8±0.0
Lipids	2.1±0.0	2.1±0.0	1.1±0.0	1.8±0.0	1.8±0.0	1.1±0.0
Fatty acids[a]						
16:0	21.4	21.5	23.5	23.5	24.9	25.4
18:0	1.2	1.3	2.0	1.2	1.3	1.9
18:1	15.3	15.4	9.1	10.4	9.9	13.2
18:2	57.3	57.3	62.0	59.6	58.6	56.5
18:3	4.5	4.5	3.4	5.3	5.1	2.9

[a] Standard errors of means varied from 0.0 to 0.2%.

TABLE V

Water Hydration Capacity, Alkaline Water Retention Capacity, and Fat Absorption of Scout and Tupper Barley Fractions (dry basis)

Property	Scout Meal	Scout Flour	Scout Pearled Flour	Tupper Meal	Tupper Flour	Tupper Pearled Flour
Water hydration capacity, ml/g	1.84 ± 0.1	1.76 ± 0.0	2.96 ± 0.0	1.76 ± 0.0	1.62 ± 0.1	1.85 ± 0.0
Alkaline-water retention capacity, % weight gain	294.7 ± 0.8	306.3 ± 2.1	386.1 ± 1.0	319.7 ± 1.3	281.5 ± 1.6	366.3 ± 3.2
Fat absorption,%[a]	101.0	68.0	113.3	137.3	90.6	103.4

[a] Standard error was 0.0% in each case.

pearled meal 14.7–16.1% protein. The protein quality of flour and pearled meal may be poor, as the aleurone layer contains lysine-rich proteins (Simmonds and Orth 1973). However, the protein content of hull-less barley may fluctuate widely. The flour fractions were low in fiber (0.9–1.1%); the pearled meals had slightly lower fiber (0.8–0.9%). Barley flour fractions contained more ash than is normally present in wheat flour (about 0.5%). The total lipid content of the meal was similar to that reported for hulled barley (Bhatty et al 1974), and it decreased relatively little in the flour fractions. The pearled meal contained a little more than half the total lipids of the meal. The major fatty acid was linoleic, which together with the second and third major fatty acids, palmitic and oleic, respectively, formed approximately 95% of the total fatty acids. There were minor variations among the individual fatty acids, particularly of the pearled meal fractions. The fatty acid composition of the fractions was, in general, similar to that reported for whole barley (Weber 1973).

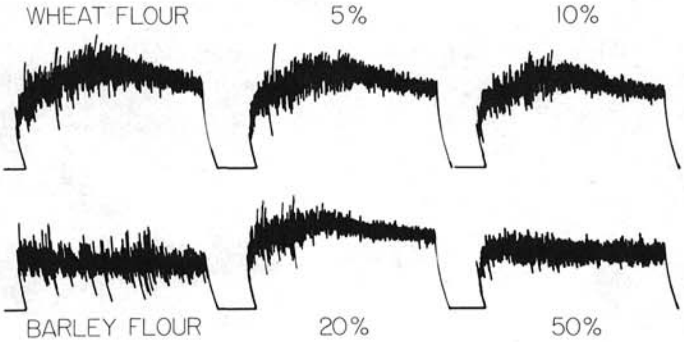

Fig. 3. Mixograms of wheat and hull-less barley flour blends: 5, 10, 20, and 50% denote percentages of barley flour added to wheat flour.

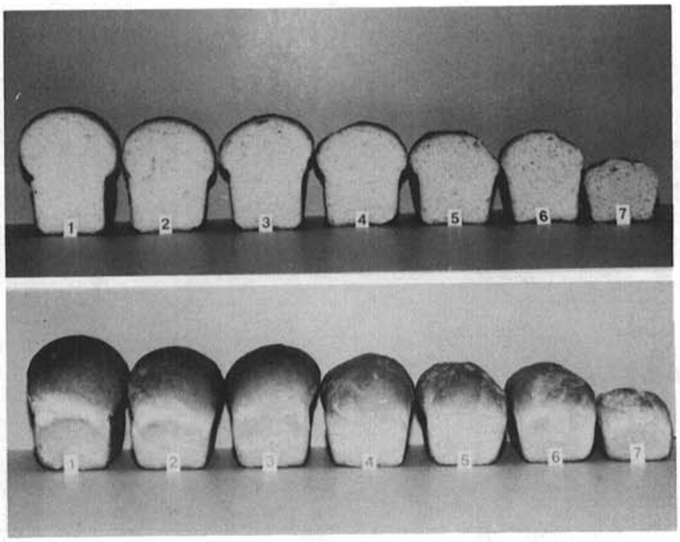

Fig. 4. External and internal appearance of loaves baked from wheat and hull-less barley flour blends. Numbers **1–7** denote 0, 5, 10, 15, 20, 25, and 50% barley flour added to wheat flour.

The water hydration capacities (WHC) of the meal and flour fractions were generally similar but WHC was higher for the pearled barley meal (Table V). Scout pearled meal absorbed water nearly three times its weight and Tupper pearled meal less than two times its weight. Similarly, the alkaline water retention capacity (AWRC) of the pearled meal fractions was higher than those of the meal and flour fractions. There was no consistent relationship between the water pH and the quantity of water held by the fractions. The WHC and AWRC of the Scout pearled meal were 54% and 31%, respectively, greater than those of the meals. In Tupper pearled meal the trend was reversed; the corresponding values were 5 and 14%. The WHC, AWRC, water binding, water absorption, and water holding ability are interchangeably used to denote water held by a material under defined conditions (Quinn and Paton 1979). Although largely a function of proteins which hold water by hydrogen bonding or by physical entrapment (Kinsella 1979), this property is influenced by other factors. In barley fractions, the nonstarch polysaccharides β-D-glucans may influence WHC and AWRC. The β-D-glucans are partially soluble in water and form viscous gels on hydration. They are primarily present (75%) in cell walls of barley endosperm (Munck 1981). The higher WHC and AWRC of Scout barley flour were probably due to its higher β-D-glucans content. The fat absorption by the fractions was not similar. Scout pearled meal absorbed more fat than did the meal. In Tupper, the meal absorbed more fat than did the pearled meal. In both the barleys, the flour fraction absorbed the least fat. There did not appear to be any relationship between fat absorption and protein content of the fractions (lipid-protein interaction). Such a relationship has been reported for fat absorption in soy preparations (Kinsella 1979).

Figure 2 shows the Viscoamylograph properties of the fractions and, for comparison, of wheat flour. The pasting temperature was recorded when viscosity increased by 20 BU. The pasting temperatures were 69° C for the barley meals, 64–66° C for the flour fractions, and 54–57° C for the pearled meal fractions. The gelatinization temperature of barley starch varies from 51 to 60° C and that of rice starch from 68 to 78° C (Lineback 1984). A gelatinization temperature range of 53–86° C has been given for barley by Bae (1979). It may thus be possible to have barley and rice cultivars with the same gelatinization temperature. Peak viscosities were 250–295 BU for meals and 260–335 BU for flour fractions compared to 460 BU for wheat flour and 775–1,060 BU for the pearled barley meals. Scout pearled meal had higher peak viscosity than did Tupper pearled meal. Although peak viscosities were probably influenced by nonstarchy constituents present in the samples, they suggested a relatively lower swelling power of barley meal and flour fractions and a much higher swelling power for the pearled flour meals. The swollen meals and flour granules were

TABLE VI
Mixograph Properties of Wheat and Hull-less Barley (Scout) Flour Blends and Characteristics of Bread Baked from the Blends[a]

	Mixogram[b]				Bread Characteristics			
Composite Flour	**Time (min)**	**Height (cm)**	**Area (cm^2)**	**Loaf Volume**	**Shape**	**Crust Color**	**Crumb Color**	**Texture**
100% WF	3:20	7.1	69.5	845±10.0	E	E	E	E
95% WF + 5% BF	3:30	6.7	66.9	742±12.5	G	G	G	G
90% WF + 10% BF	3:40	6.4	64.5	722± 2.5	G	G	G	G
85% WF + 15% BF	3:30	6.3	62.7	653± 2.5	P	P	P	P
80% WF + 20% BF	3:20	5.8	60.3	572± 2.5	...	...	...	...
75% WF − 20% BF	3:10	5.4	56.8	545± 5.0	...	...	...	...
50% WF + 50% BF	No peak		44.7	<400	...	...	...	...
0% WF + 100% BF	No peak		38.3		...	...	...	...

[a] WF, wheat flour; BF, barley flour; E, excellent; G, good; P, poor.
[b] Single determination.

generally stable compared to the pearled meal fractions, where the difference between the peak viscosity and viscosity at the end of the holding period was greater, indicating the fragility of the swollen granules. The setback viscosities (viscosity after cooling to 50°C), except for the pearled meal fractions, were lower than for wheat flour. The setback viscosity indicates the ability of the hot paste granules to aggregate or retrograde on cooling. The high swelling power of the pearled meal fractions was most likely caused by β-D-glucans, which on cooling formed more viscous gels, giving higher setback viscosities. High peak viscosities are typical of pearled barley and have been reported by others (Sumner et al 1985, Cheigh 1979), but the data were difficult to compare because different sample preparations and concentrations were used.

Table VI gives the mixogram data for wheat-barley composite flours and characteristics of bread baked from these flours. Dough development times of the composite flours were not substantially altered by addition of up to 20% barley flour. However, both peak height and area decreased in a linear manner on addition of 5–50% barley flour to wheat flour. The reduction in peak height and area suggested that barley flour proteins have some extensibility. However, they lack stability and resistance to mixing even in the presence of a dough improver (SSL). At the 50% level of barley flour no peak was obtained, and the mixogram pattern was similar to that of 100% barley flour. Figure 3 shows typical mixograms of composite flours containing 5, 10, 20, and 50% barley flour added to wheat flour as well as those of 100% wheat and barley flours. The characteristics of bread baked from the composite flours confirmed data obtained with the mixograph. Not more than 5% (possibly 10%) barley flour could be added to wheat flour without seriously affecting loaf volume and appearance (Fig. 4). Higher levels of barley flour bring about dilution of wheat gluten and impairment of its gas retention capacity. At the 5% barley flour level, loaf volume was decreased by 103 cc (14%), although the bread was of acceptable quality. An earlier study (Cheigh 1979) also reported an acceptable bread produced from a 5–10% wheat-barley composite flour.

CONCLUSIONS

Hull-less barley grain, because of its low fiber, and products such as meal, flour, and pearled meal have many applications in food products. The flour may be used as a hard wheat flour extender in baking of bread and as a thickening agent in soups and other culinary dishes. However, one disadvantage of hull-less barley, like hulled barley, is its β-D-glucan content. These nonstarchy polysaccharides, being partially soluble in water, increase the viscosity of barley pastes that may be undesirable in some food applications. Although β-D-glucans are easily hydrolyzable by externally added β-D-glucanases, their removal by plant breeding could enhance the use of hull-less barley in food and feed applications.

ACKNOWLEDGMENTS

This research was supported by a grant from the College of Agriculture Hantelman Trust Fund. Acknowledgment is given to A. K. Sumner for use of the equipment and to G. Pocha, K. Wu, and B. Ng for technical assistance.

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[Received April 23, 1985. Revision received July 15, 1985. Accepted July 15, 1985.]