Comparison of Pearled and Unpearled Canadian and Japanese Barleys

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ABSTRACT

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Canadian and Japanese barleys were compared for whole and pearled grain composition and starch properties. Whole grain color and composition of the barleys showed large intercultivar differences, but few (color, protein, and total dietary fiber) significant differences between the Canadian and Japanese barleys. The Canadian hull-less barleys (HB) were pearled to 55% yield to match pearl yields of Japanese barleys. In Canadian HB, pearl time was correlated (r^2 = +0.96**) with grain hardness. There were large intercultivar differences in color and composition of the pearled barleys; only protein, starch, total dietary fiber, and viscosity showed significant differences between the Canadian and Japanese pearled barleys. Pasting properties of the four Canadian pearled barleys (CDC Candle, AC Hawkeye, Falcon, and CDC Richard) and three Japanese pearled barleys (Hinode, Ichiban-Boshi, and Minori) showed Canadian pearled barleys had higher peak viscosity, viscosity at 95°C, and setback viscosity than the Japanese barleys. These differences in pasting properties were not related to amylose or crude lipid contents of Canadian and Japanese pearled barleys, nor to swelling factor and thermal properties of starches isolated from the barleys. They were likely due to higher β-glucan and protein in starch slurries of Canadian HB.

Hull-less barley (HB) was grown on more than 0.2 million hectares in Western Canada in 1997. This production is likely to double or even triple in the next five years. Although almost all of the Canadian production of HB is used in swine feed, this grain is on the threshold of breaking into several food and industrial uses. Several HB cultivars have been registered in Canada, containing low or high β-glucan and waxy (low amylose) starch.

Barley has multiple uses in the food industry in Japan and Korea. For a majority of these applications, barley is pearled and split. Pearled barley and rice combination is a fast-growing food product in Japan and is promoted to increase dietary fiber intake. Ikegami et al (1996) reported a significant decrease in serum lipids (total cholesterol, LDL cholesterol, phospholipids and LDL, and VLDL lipoprotein) in hypercholesterolemic Japanese men and in mildly hypercholesterolemic Japanese women fed boiled barley-rice mix (50:50, w/w). Such studies are likely to encourage the use of HB as rice extender in Japanese diets as HB, especially waxy HB, contains more β-glucan (Bhatty 1992), a major component of soluble dietary fiber, than does regular or normal starch barley.

Several quality criteria such as a round shape, light yellow color, waxy starch (for the preparation of miso), kernel plumpness, uniformity, absence of hard or steely kernels (determined visually), and high starch content (for the production of *Sochu*) are considered desirable in barleys used by Japanese pearlers. Chemical quality criteria are not mentioned except waxy or high amylopectin starch. All of the above criteria are available in Canadian HB, which requires less pearling time and no hull disposal. Furthermore, the outercoverings of HB (bran) removed during pearling are an excellent source of dietary fiber due to β-glucan enrichment.

This article reports physicochemical properties of pearled and unpearled Canadian and Japanese barleys. The objective was to obtain comparable data on barleys from the two countries for use by trade and industry as such data have not been reported in the literature.

MATERIALS AND METHODS

Japanese Barleys

Four cultivars of Japanese barley, Hinode, Ichiban-Boshi, Minori, and Shunrai, were obtained from the Japanese Food Barley Group, which visited Western Canada in the summer of 1994. This group included S. Nakashima, T. Nagasawa, and T. Hiyama; the latter represented All Japan Barley Processors Association, Tokyo. Three of these cultivars, Ichiban-Boshi, Minori, and Shunrai, were pearled (in Japan) to 55% yields and were available only in gram quantities. In 1995, following their visit, T. Hiyama sent, on request, kilogram quantities of Hinode, Ichiban-Boshi, and Minori. These cultivars were probably used most commonly by the Japanese barley processors. The year of growth or growth locations of the cultivars were not given. They are identified in this study by the year in which they were received. Ichiban-Boshi and Hinode were hull-less and Minori and Shunrai were hulled barleys. Minori 1995 was dehulled in our laboratory by removing ≈15% of its outercoverings in a Satake mill (model 05, Satake Corp., Tokyo). Shunrai and Minori 1994 were not dehulled due to lack of sufficient seed.

Canadian Barleys

Twelve registered cultivars of Canadian HB were obtained from the 1994 Western Hull-less Barley Cooperative Test grown at the Kernen Crop Research Farm, University of Saskatchewan, Saskatoon. The Canadian cultivars were 2- and 6-rowed and included three waxy cultivars, CDC Candle, Merlin, and HB803, containing ≈5% amylose.

The 12 Canadian HB and the three 1995 Japanese barleys were pearled to 55% yield in a Satake mill to match the 1994 Japanese pearl yields. Pearl time was adjusted to obtain the same pearl yield (55%) in each case. Subsamples of the pearled and unpearled barleys were ground in a cyclone mill (Udy Corp., Fort Collins, CO) to pass a 0.5-mm screen, and the ground barleys were stored at 5°C.

Methods

Grain hardness was determined with a micro-hardness tester (C.W. Brabender, South Hackensack, NJ) that automatically recorded time required to mill 4.0 g of grain. Color (white) of ground barley was measured using a spectrocolorimeter (Hunterlab Color-Quest, Hunter Assoc. Laboratories, Reston, VA) standardized with a white tile.

Analyses

Approved methods (AACC 1995) were used to determine moisture (44-19), ash (08-03), protein (N × 6.25) (46-13), crude lipids (30-25), and starch damage (76-31). β-Glucan was determined by the method of McCleary and Glennie-Holmes (1985). Starch was determined by the method of Holm et al (1986) after boiling with 80% ethanol for 30 min. Amylose was determined by the method of Chrastil (1987). Total and soluble fiber were determined by the method of Prosky et al (1988). Viscosity of acid extract of ground barleys was measured using a digital viscometer

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(model DV-II, Brookfield Engineering Lab., Stoughton MA) at 20°C (Bhatty 1992). Viscoamylograph properties of selected Canadian and Japanese barleys were determined with a Brabender Viscoamylograph on 8% starch suspension in water, containing 200 mg of mercuric acetate as α-amylase inhibitor. Gelatinization temperature was taken when viscosity increased to 10 BU.

Starch was isolated from ground barley as described previously (Vasanthan and Bhatty 1995). Swelling factor of isolated starches was determined by the direct method of Tester and Morrison (1990). Starch gelatinization was determined with a differential scanning calorimeter (Mettler 4000). Water concentration in the samples was 77%. The scanning temperature range and heating rate were 20–120°C and 10°C/min, respectively. The thermograms were recorded with water as reference.

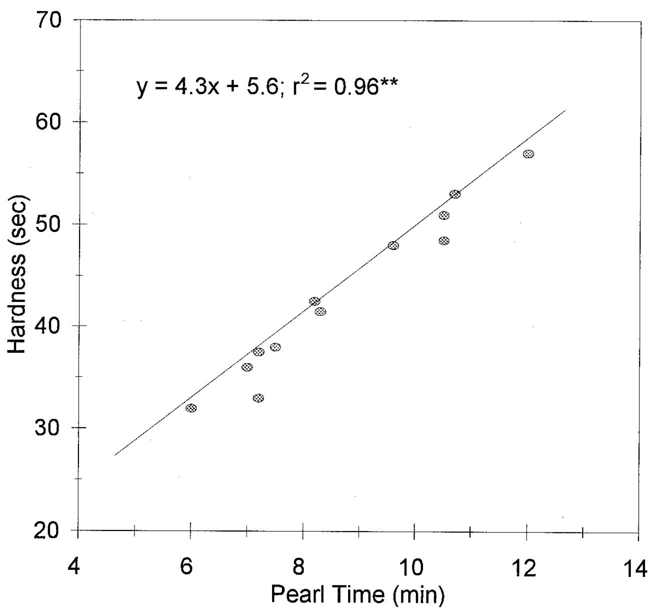

Fig. 1. Relationship between pearl time and grain hardness in Canadian hull-less barleys.

Statistical Analysis

All data are reported on moisture-free basis and are means of at least duplicate determinations which were used for statistical analysis. A paired *t*-test was used to compare differences between the two mean values. Least significant differences were calculated from analysis of variance (Minitab Statistical Software).

Brightfield Microscopy

Kernels were broken open transversely, fixed in glutaraldehyde, dehydrated through an ethanol series, and embedded in glycol methacrylate resin. Sections (2 µm thick) were cut and stained with: 1) Periodic acid/Schiff for carbohydrate-starch granules, counterstained with Sudan Black for lipid-cuticle, or 2) Amido Black B for protein. Stained sections were examined in a Leitz Orthoplan brightfield microscope. Photomicrographs were recorded on Kodak Royal Gold 400 film.

RESULTS AND DISCUSSION

Barleys

The availability of only four cultivars of Japanese barley, two hulled and two hull-less grown in Japan, compared to 12 Canadian cultivars of HB, grown under identical conditions, including three waxy starch cultivars, allowed an uneven comparison between the Canadian and Japanese barleys. Furthermore, the Japanese barleys were winter grown and the Canadian HB were spring grown. Nevertheless, the study generated comparative data on Canadian and Japanese barleys previously not available in the literature. Ichiban-Boshi is considered the best cultivar for food use in Japan, followed by Shunrai and Minori, although no specific data were available to us for such a ranking of these cultivars. Therefore, the three Japanese cultivars, Ichiban-Boshi, Shunrai, and Minori,

TABLE I
Composition of Canadian and Japanese Cultivars of Barley

Barley	Hardness (sec)	Color (*L*)	Ash (%)	Protein (%)	Starch (%)	β-Glucan (%)	TDF[a] (%)	SF[b] (%)	Viscosity (cps)
Japanese, 1994									
Hinode (Hull-less)	27	81.8	1.9	10.8	76.9	4.1	15.7	3.8	5.7
Ichiban-Boshi (Hull-less)	26	82.3	2.0	10.1	77.3	3.9	15.0	3.7	7.4
Minori	52	78.9	2.8	9.8	69.5	5.4	21.0	5.2	4.8
Shunrai	63	82.6	2.3	12.6	66.8	5.3	19.6	3.7	32.9
Japanese, 1995									
Hinode	87	83.4	2.1	11.3	67.4	4.6	17.3	3.9	4.8
Ichiban-Boshi	108	84.1	2.2	10.4	71.5	3.8	15.9	3.6	4.8
Minori (dehulled)	53	84.4	1.7	8.7	71.1	5.4	13.6	4.7	2.9
Mean	59	82.5	2.1	10.5	71.5	4.6	16.9	4.1	9.0
LSD ($P < 0.01$)	9	1.2	0.2	0.6	4.1	0.5	1.4	0.6	0.6
Canadian, 1994 (Hull-less)									
CDC Buck	43	85.4	1.8	13.6	70.7	5.4	14.0	3.2	26.7
CDC Candle[c]	57	84.1	2.1	15.6	62.0	8.0	16.6	6.4	469.0
CDC Dawn	53	84.5	1.8	12.8	74.5	4.6	11.6	3.1	7.1
CDC Richard	38	82.8	2.1	13.3	69.3	4.1	13.9	3.7	8.7
Condor	51	84.2	2.0	15.8	67.8	6.4	14.8	3.8	26.0
Falcon	38	85.2	1.8	16.1	65.8	4.8	12.6	3.7	20.3
Merlin[c]	42	83.7	1.9	16.8	60.1	6.4	15.9	5.9	45.3
Phoenix	49	84.4	2.2	16.5	66.4	5.1	13.0	3.5	23.5
AC Hawkeye	36	86.0	1.9	15.3	73.8	4.8	12.8	4.1	12.9
HB317	33	84.7	2.0	15.9	67.0	5.5	12.1	4.6	34.3
HB320	32	83.3	2.1	16.5	69.3	4.1	11.0	3.2	20.6
HB803[c]	48	84.3	2.1	17.8	63.4	7.7	14.6	6.0	75.9
Mean	43	84.4	2.0	15.5	67.5	5.0[d]	12.9[d]	3.6[d]	20.0[d]
LSD ($P < 0.01$)[e]	5 ns	0.2*	0.2 ns	0.7**	6.0 ns	0.4[d] ns	1.7[d]**	0.5[d] ns	1.1[d] ns

[a] Total dietary fiber.
[b] Soluble fiber.
[c] Waxy cultivars.
[d] Excluding the waxy cultivars.
[e] *t* test between the Canadian and Japanese means; $P < 0.01$ (**), $P < 0.05$ (*), not significant (ns). LSD = least significant difference.

were taken as standards in comparing Canadian and Japanese barleys. Unfortunately, Shunrai was not available in 1995 for more detailed analyses as were Ichiban-Boshi and Minori. The major distinguishing physical feature of Japanese barleys was small seed size with a mean 1,000 kernel weight of 27 ± 4 g (n = 7) compared to 40 ± 4 g (n = 12) for the Canadian HB.

Composition

Table I gives data on grain hardness, color, and analytical composition of the Canadian and Japanese barleys. The 1994 Japanese barleys were harder with a grind time of 27–63 sec compared to the 1995 samples, which were softer, particularly cultivars Hinode and Ichiban-boshi, with grind times of 53–108 sec; the shorter

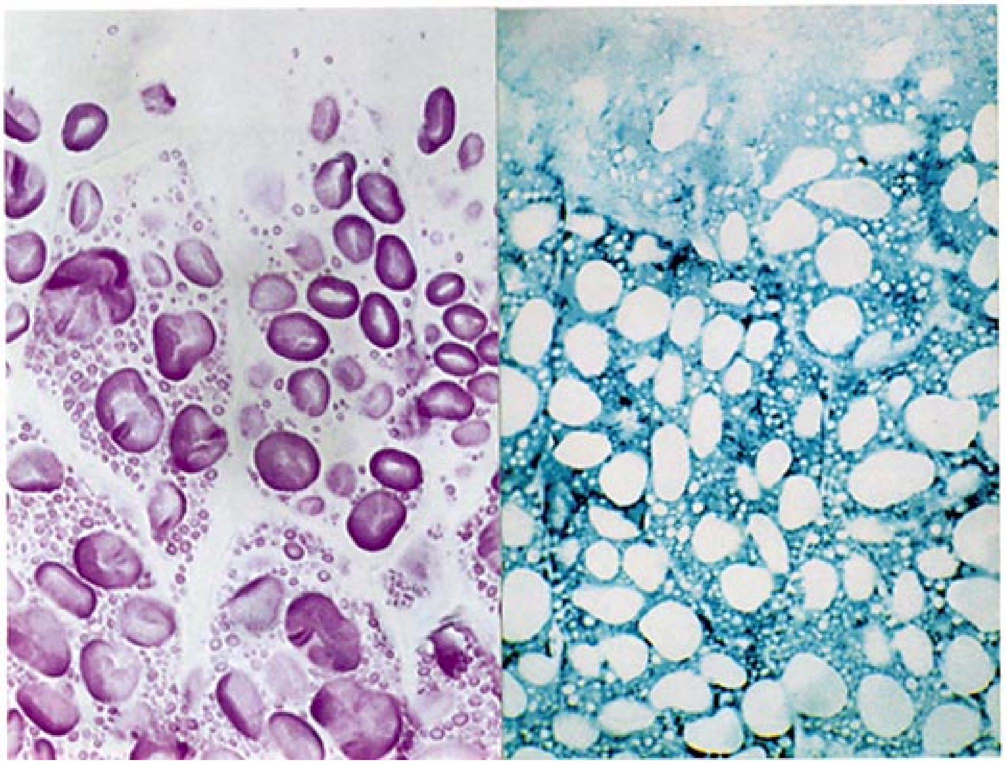

Fig. 2. Photomicrographs of Condor hull-less barley pearled to 55% and stained with Periodic acid/Schiff for starch (left) and Amido Black B for protein (right).

TABLE II
Composition of Japanese and Canadian Cultivars of Barley Pearled to 55% Extraction in a Satake Mill

Barley	Color (L)	Ash (%)	Protein (%)	Starch (%)	β-Glucan (%)	TDF[a] (%)	SF[b] (%)	Viscosity (cps)	Starch Damage (%)
Japanese, 1994									
Ichiban-Boshi (Hull-less)	91.7	0.6	5.7	91.2	3.5	7.5	2.5	10.3	4.8
Minori	89.7	0.6	6.6	90.4	5.5	9.8	5.0	7.4	4.5
Shunrai	91.1	0.6	8.1	88.2	5.6	9.1	4.5	49.8	3.5
Japanese, 1995									
Hinode	90.5	0.5	6.7	87.5	4.7	8.9	3.5	6.9	5.1
Ichiban-Boshi	91.1	0.6	6.9	91.0	3.5	7.9	2.8	7.2	3.9
Minori (dehulled)	89.7	0.6	5.8	83.6	5.4	9.3	5.0	3.4	5.6
Mean	90.6	0.6	6.6	88.7	4.7	8.8	3.9	14.2	4.6
LSD (P < 0.01)	0.5	0.0	0.8	3.1	0.4	1.0	0.5	2.7	0.4
Canadian, 1994 (Hull-less)									
CDC Buck	91.3	0.6	8.6	79.7	5.8	8.1	3.7	35.7	3.9
CDC Candle[c]	91.6	0.6	8.5	69.1	7.7	9.2	5.7	786.9	4.5
CDC Dawn	90.2	0.6	8.8	83.2	4.8	6.6	2.8	22.7	3.3
CDC Richard	90.8	0.6	8.1	83.7	4.0	6.9	2.8	23.2	3.4
Condor	91.0	0.5	9.4	85.5	6.0	8.0	5.0	41.0	3.7
Falcon	90.9	0.5	9.2	79.8	4.9	7.2	3.4	35.3	3.2
Merlin[c]	90.0	0.6	10.2	80.1	6.5	9.6	5.2	147.9	4.2
Phoenix	90.7	0.6	9.0	81.3	4.9	7.0	2.3	43.5	3.5
AC Hawkeye	91.4	0.6	8.8	78.7	5.0	7.7	3.3	18.9	3.7
HB317	91.1	0.6	8.3	83.2	5.0	7.9	3.9	53.7	4.4
HB320	90.3	0.6	9.6	87.6	3.9	6.5	3.1	49.2	3.2
HB803[c]	90.1	0.6	9.2	74.8	7.4	10.2	6.8	144.1	5.1
Mean	90.8	0.6	9.0	81.4	4.9[d]	7.3[d]	3.4[d]	35.9[d]	3.8
LSD (P < 0.01)[e]	0.2 ns	0.1 ns	1.0**	6.0**	0.4[b] ns	1.3[d]**	0.9[d] ns	3.3[d]*	0.3 ns

[a] Total dietary fiber.
[b] Soluble fiber.
[c] Waxy cultivars.
[d] Excluding the waxy cultivars.
[e] t test between the Canadian and Japanese means; P < 0.01 (**), P < 0.05 (*), not significant (ns). LSD = least significant difference.

grind time indicates harder grain and longer time softer grain. The likely reason for the yearly difference in grain hardness, with the exception of cultivar Minori, was moisture content as determined in our laboratory by surface drying the whole grain. The 1994 Japanese cultivars had, on average, only 4% moisture compared to 10% moisture for the 1995 samples. No reason can be given for similar hardness of cultivar Minori from 1994 and 1995, in spite of differences in grain moisture, except that it was hulled, unlike Hinode and Ichiban-Boshi. The hardness means for the Japanese and Canadian barleys were not significantly different. The Japanese barleys were slightly darker (*L* values), had lower protein, and higher total dietary fiber (TDF) than the Canadian HB. The latter difference was due to 1994 Minori and Shunrai, which were hulled. The Canadian and Japanese barleys had similar ash, starch, β-glucan, soluble fiber (SF), and viscosity. In the Japanese barleys, starch content varied from 67 to 77%. In the Canadian barleys, the variation was larger (62–74%), due to low starch content of the two waxy starch cultivars, CDC Candle (62%) and HB803 (63%); starch content was not negatively correlated with protein content. The Canadian HB, excluding the waxy cultivars, which had the highest level of β-glucan (6–8%), contained similar levels of β-glucan as the Japanese barleys (5.0 vs. 4.6%). Acid-extract viscosity (AEV), a measure of soluble β-glucan, was similar in the Canadian and Japanese barleys when the waxy cultivars were excluded from comparison due to high AEV, especially of cultivar CDC Candle.

The data in Table I were also used to compare means of three Japanese HB, Ichiban-Boshi 1994 and 1995, and Minori (dehulled in our laboratory), the two more popular barleys in Japan, with the means of Canadian HB (data not given). There were no significant differences between the means (*t*-test) of Canadian and Japanese barleys for grain hardness, color, ash, starch, β-glucan, TDF, and SF. Statistically significant differences were found only for protein and AEV.

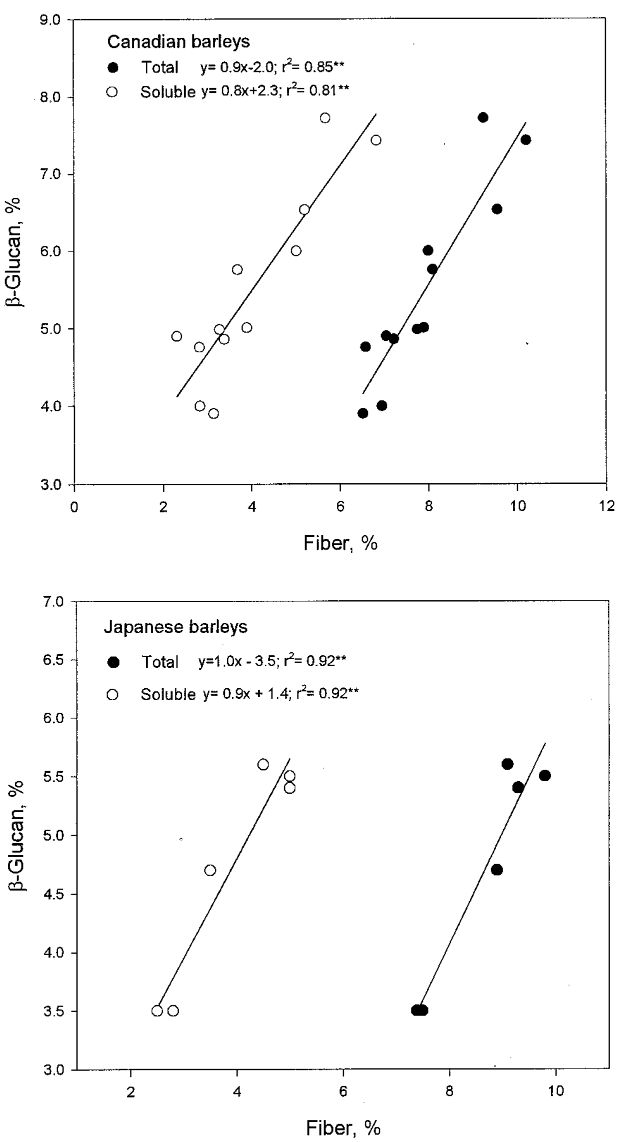

Fig. 3. Correlations between β-glucan and dietary fiber in pearled Canadian and Japanese barleys.

Pearled Barleys

The 12 Canadian HB and the three 1995 Japanese barleys were pearled to 55% yield in our laboratory to match pearl yields of the 1994 Japanese barleys pearled in Japan. In the Canadian HB, pearl time was significantly ($P < 0.01$) correlated with grain hardness (Fig. 1), as softer cultivars required longer time to pearl than the harder cultivars. The five Canadian HB (HB320, HB317, AC Hawkeye, Falcon, and CDC Richard) had grain hardness of <40 sec and were harder than the rest. Three of these HB (AC Hawkeye, Falcon, and CDC Richard) are registered cultivars and in commercial production, unlike HB317 and HB 320, which are defunct.

One pearled cultivar of Canadian HB (Condor) was examined under brightfield microscope to determine structural changes on pearling HB to 55% yield (Fig. 2). The micrographs show only inner endosperm with bi-modal starch granules (stained pink; left) embedded in the protein matrix (stained blue; right). There was no evidence of the presence of the grain's outercoverings (testa, pericarp, aleurone, and subaleurone). This structure was typical of other barleys pearled to 55%. Pearled Condor HB was whiter; pearling reduced ash by 75%, protein by 41%, β-glucan by 6%, and TDF by 46% as compared with unpearled Condor HB. These data were calculated from Tables I and II. Only starch and SF increased on pearling by 26 and 32%, respectively.

Table II gives the comparative composition of pearled Canadian and Japanese barleys. The means for Canadian and Japanese barleys were significantly different for protein, starch, TDF, and viscosity. Surprisingly, there was little or no decrease in β-glucan (and SF) on pearling Canadian and Japanese barleys. In both the Canadian and Japanese barleys, starch damage was low and varied only from 4 to 5%. In overall comparison, pearled Canadian HB had the same whiteness (*L* value) as the Japanese pearled barleys, but higher protein, lower starch, and lower TDF. The acid extracts of the Canadian barleys were three times more viscous than the Japa-

TABLE III
Swelling Factors of Starches Isolated from Canadian and Japanese Barleys at Five Temperatures

Barley	50°C	60°C	70°C	80°C	95°C
Canadian					
AC Hawkeye	4.4	7.1	8.5	11.7	25.8
CDC Dawn	5.4	8.6	12.6	13.2	31.2
CDC Richard	2.5	7.3	8.2	11.6	26.9
Condor	7.0	8.1	14.2	15.4	29.7
Falcon	4.1	8.0	8.7	12.0	24.1
Mean	4.7	7.8	10.4	12.8	27.5
LSD ($P < 0.01$)	4.6	1.9	3.0	3.4	6.4
Japanese					
Hinode	7.3	8.1	11.6	13.4	33.1
Ichiban-Boshi	7.1	8.0	12.3	14.1	32.2
Minori	10.5	12.4	12.9	13.6	31.8
Mean	8.3	9.5	12.3	13.7	32.4
LSD ($P < 0.01$)	6.0	1.4	4.1	10.9	8.5
t-test[a]	ns	ns	ns	ns	*

[a] *t* test between the Canadian and Japanese means; $P < 0.01$ (**), $P < 0.05$ (*), not significant (ns). LSD = least significant difference.

nese barleys. β-Glucan content was positively correlated with TDF and SF in both the Canadian and Japanese pearled barleys (Fig. 3). Japanese barleys contained more TDF than the Canadian HB. Data in Tables I and II suggested that differences in grain color and gross chemical composition of pearled and unpearled Canadian and Japanese barleys were small and variable. In many cases, there were greater intercultivar differences than differences between the Canadian and Japanese barleys.

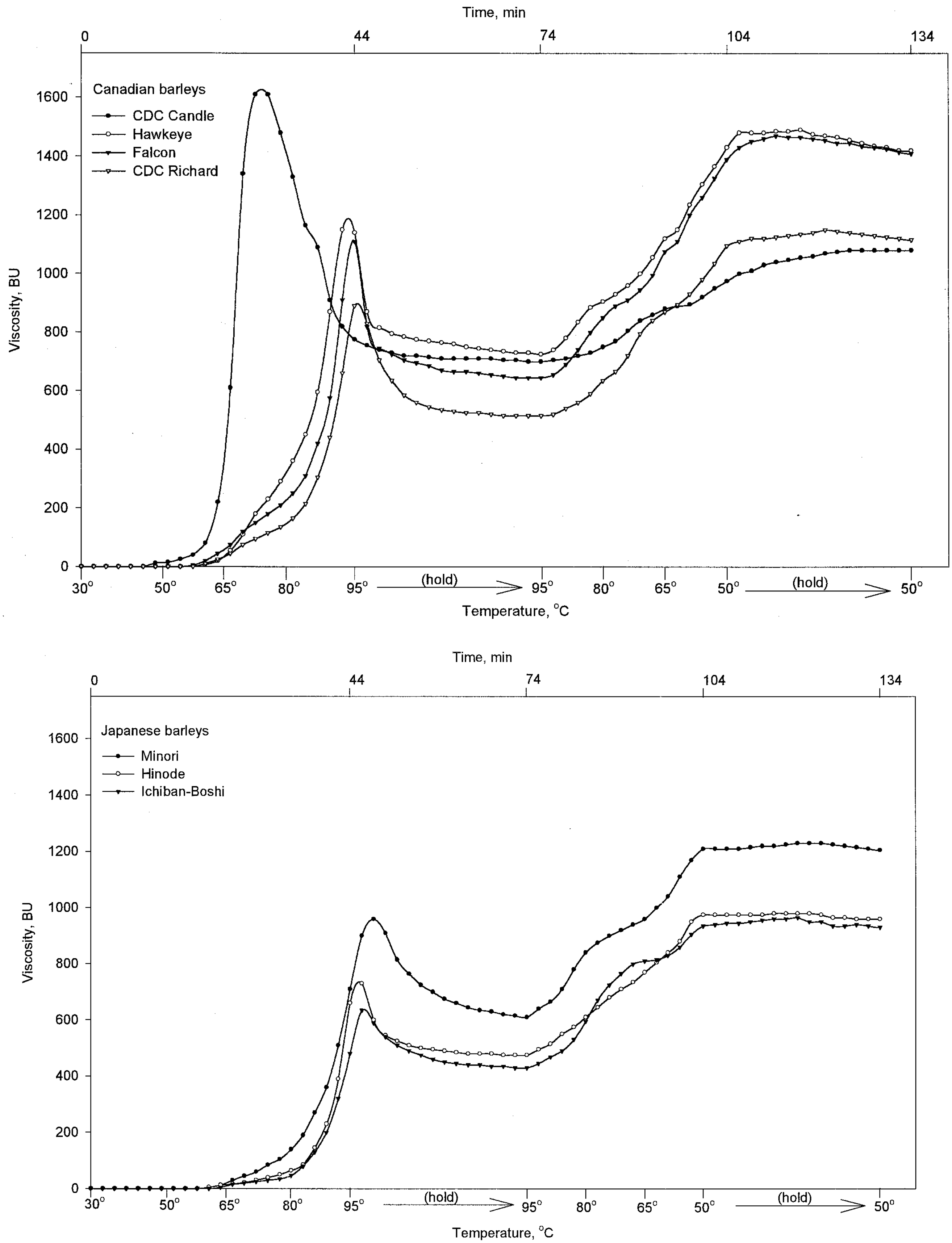

Fig. 4. Viscoamylographs of selected cultivars of Canadian and Japanese barleys pearled to 55% yields. Slurry concentration was 8% starch.

TABLE IV
Thermal Properties of Starches Isolated from Canadian and Japanese Barleys

Barley	Onset (T_o)	Peak (T_p)	Conclusion (T_c)	Range (°C)	Enthalpy (J/g)
Canadian					
AC Hawkeye	56.2	62.5	72.2	16.0	11.5
CDC Candle	57.8	63.0	71.1	13.3	13.7
CDC Dawn	54.6	59.6	67.4	12.9	11.1
CDC Richard	57.1	62.5	72.2	15.1	11.0
Condor	55.0	60.8	70.0	15.0	11.6
Falcon	54.4	60.5	57.5	13.2	9.7
Mean	55.9	61.5	70.1	14.3	11.4
LSD ($P < 0.01$)	4.1	1.2	3.5	1.3	1.4
Japanese					
Hinode	53.7	58.5	66.8	13.2	8.8
Ichiban-Boshi	53.9	58.9	68.6	14.7	9.7
Minori	56.0	60.8	69.4	13.5	10.9
Mean	54.5	59.4	68.3	13.8	9.8
LSD ($P < 0.01$)	2.0	–	5.4	7.6	9.1
t-test[a]	ns	ns	ns	ns	ns

[a] *t* test between the Canadian and Japanese means; $P < 0.01$ (**),$P < 0.05$ (*), not significant (ns). LSD = least significant difference.

Starch Characteristics

Starch was the major component of the pearled barleys. The Canadian barleys contained on average 81%, and the Japanese barleys contained 89% starch (Table II). Three Japanese cultivars, Hinode, Ichiban-Boshi, and Minori 1995, and four cultivars of Canadian HB were used to determine starch properties. The four Canadian cultivars included CDC Candle (because of its waxy starch), Falcon, AC Hawkeye, and CDC Richard, which were the hardest as determined by grain hardness (Fig. 1). Figure 4 shows viscoamylographs of the four Canadian and three Japanese pearled barleys. The pasting behavior of CDC Candle, a waxy starch cultivar containing 5% amylose, showed low gelatinization temperature (48°C) compared to those of the regular starch Canadian (59–62°C) and Japanese (61–64°C) barleys. The three Canadian HB contained 26–30% amylose, and the three Japanese barleys contained 27–31% amylose; their means were not significantly different (data not given). The peak viscosity of CDC Candle was the highest (1,630 BU), while the three other Canadian cultivars had peak viscosities of 890–1,200 BU, which were higher than those of the three Japanese cultivars (625–960 BU). Within the regular-starch Canadian or Japanese pearled barleys, peak viscosities were related, as expected, to starch content (8% starch slurry in each case). Linear regression showed a highly significant correlation ($r = 0.99$, $n = 6$, $P < 0.001$) between peak viscosity and starch content of Canadian and Japanese pearled barleys. As the Canadian pearled HB contained less starch than the Japanese pearled barleys (Table II), more material was added, in the case of Canadian pearled HB, to obtain an 8% starch slurry. This resulted in higher concentrations of β-glucan and protein in starch slurries of Canadian pearled HB than in the Japanese pearled barley. The calculated weights of β-glucan in the Canadian and Japanese pearled barley slurries were 1.9–2.5 g (mean 2.3 g) and 1.5–2.4 g (mean 2.0 g), respectively. The corresponding values for protein were 3.9–4.5 g (mean 4.3 g) and 2.7–3.0 g (mean 3.0 g). Therefore, the higher β-glucan and protein of Canadian HB starch slurries were largely, if not entirely, responsible for higher peak viscosities as neither the swelling factors (Table III), amylose, nor crude lipid contents of Canadian and Japanese pearled barleys were significantly different. Water-soluble β-glucans are asymmetrical molecules with DP 900–1,800 that produce high viscosities in aqueous solutions even at low concentrations. Protein may undergo denaturation or may complex with starch and β-glucan and thereby contribute to viscosity. Morris et al (1997) listed several variables such as gluten, starch tailings, and the water-soluble fraction, that affected peak paste viscosity of wheat flour, although prime starch was the primary determinant of flour paste viscosity.

The 95°C viscosity of CDC Candle was 775 BU, 855 BU less than the peak viscosity, suggesting fragility of the swollen low-amylose starch granules. Its viscosity increased to 975 BU at 50°C and to 1,080 BU on holding at this temperature for 30 min (setback viscosity) due to reassociation or retrogradation of the starch molecules. High peak viscosity and low resistance to viscosity breakdown in CDC Candle was typical of waxy starches. The three regular starch Japanese cultivars had lower 95°C viscosities (480–710 BU) than those of the Canadian cultivars (Fig. 4). Similarly, the Japanese cultivars had lower viscosities when held at 50°C for 30 min (950–960 BU) than the Canadian cultivars (1,115–1,420 BU). To further explain differences in pasting properties of the Canadian and Japanese barleys, starches were isolated from the barleys in 96–98% yields and their swelling factors and thermal characteristics were determined. Swelling factors (usually proportional to peak viscosity) over a range of 50–95°C were significantly different only at 95°C between the Canadian and Japanese barley starches (Table III). The higher swelling factor at this temperature for the Japanese barley starch did not explain the lower pasting viscosities shown in Fig. 4. Similarly, there were no significant differences in the thermal properties of Canadian and Japanese barley starches (Table IV), although pasting behavior is largely attributed to starch gelatinization. Thus, swelling factor and thermal properties of starch were not responsible for the differences in pasting characteristics of Canadian and Japanese pearled barleys.

CONCLUSIONS

Data reported here suggested that differences in composition of selected Canadian and Japanese barleys were small and variable and unlikely to have a major influence on their functionality in Japanese food products. The low pasting viscosities of starch from the three Japanese barleys or conversely high pasting viscosities of the three Canadian HB, were largely, if not entirely, due to β-glucan and protein contents of starch slurries of Canadian HB.

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