Plant Res. 4(3) 140~146(2001)

β -glucan Contents and Their Characteristics of Winter Cereals According to Particle Sizes and Milling Recoveries

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ABSTRACT

This study was conducted to investigate the β-glucan contents and their characteristics of winter cereals according to particle sizes and milling recoveries. Sieved fractions differed in their average contents of β-glucans, and the coarse fraction had higher contents of β-glucan than finely milled fractions. In all winter cereals, the β-glucan contents of raw flours were higher than those of their brans, and the highest β-glucan contents of every cereals were observed at 100 mesh > or 100-140 mesh fractions except the Chalssalbori fractions which showed the higest β-glucan contents (12.9%) at 140-200 mesh fraction. As compared with the β-glucan content of Chalbori among the various milling recoveries, the β-glucan was distributed more evenly throughout the endosperm but β-glucan content in bran of Chalbori was only 1.5%. However, β-glucan content of Chalssalbori (hull-less waxy barley) was the highest in the subaleurone region (8.2%) and declined slightly toward inner layers of grain. This results suggest that β-glucan distribution between high (Chalbori) and low β-glucan barley (Chalssalbori) may explain the difference in milling performance of barley. On the other hand, β-glucan contents of two rye varieties (Chilbohomil, Chunchoohomil) were lower than those of two waxy barley varieties, and the higest β-glucan contents were observed at the 60% milling recoveries. In all winter cereals, the L-values (lightness) of raw flours were higher than those of brans. And the L-values of barley varieties were higher than those of oat and rye varieties. As the particle sizes and milling recovery ratios were decreased, the L-value were increased. The a-values (redness) in brans of every winter cereals were higher than those of every particle size flours and every milling ratio fractions, and this tendency was observed in the b-values (yellowness) of every particle size of cereal flours. The L and b-value of barley, the b-value of oat, and L, a, b-value of rye have the significant relationship with the β-glucan contents, respectively. This results represent the fact that β-glucans affected the color of the flours and pounded grains of winter cereals.

Key Words : *barley, β-glucan, Huter color value, milling recoveries, oat, particle size, rye*

INTRODUCTION

The β-glucans [(1-3, 1-4)-β-D-glucan], polysaccharide or soluble fiber, are frequently founded in endosperm cell walls of cereals. β-glucans occur in highest amounts in the endosperm of barley and oats (Fincher & Stone, 1986).

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Rye is a dietary fiber and starch-rich cereal, and the dietary fiber content has been reported to ranged 13 and 17%. The major dietary fiber of rye is arabinoxylan, (1-3),(1-4)-β-D-glucan and cellulose (Nilsson *et al.*, 1996).

β-glucans form cylindrical molecules containing up to about 250,000 glucose residues that may produce cross-links between regular areas containing consecutive cellotriose units. They form thermoreversible infinite network gels. High molecular weight β-glucans are viscous due to labile cooperative associations whereas lower molecular weight β-glucans can form soft gels as the chains are easier to rearrange to maximize linkages (Anderson & Bridges, 1993). Barley β-glucan is highly viscous and pseudoplastic, both properties decreasing with increasing temperature. β-glucans have received a lot of attention due to having important positive health benefits centered around their benefits in coronary heart disease, cholesterol lowering, reducing the glycemic response and stimulating the immune system although it may be that some of these effects are due to appetite suppression (Kahlon et al., 1993; Klopfenstein & Hosenney, 1987; Newman, 1989). For this reasons, barley and oat have been regarded as the prime cereals which provide the medical and health benefits.

β-glucan are located mainly in the cell wall of endosperm, and many reports have been described the methods for laboratory and commercial milling of winter cereals to obtain β-glucan enriched products (Kiryluk et al., 2000).

Bhatty (1997) reported that dry milling of barley (hull-less) in the Buhler mill gave the better flour yield than those of tempered (9-16% moisture) barley, and the flour yield of waxy barley was lower than the regular barley mainly due to higher β-glucan content rather than grain hardness.

Prior to incorporation of cereal β-glucans into food products, it is essential that their influence on processing parameters and product quality be investigated. The objective of this study was to investigate the β-glucan contents and their characteristics of winter cereals according to milling recoveries and particle sizes.

MATERIALS AND METHODS

Ten winter cereal varieties used in this experiment were obtained from the experimental field of National Crop Experiment Station, Suwon, Korea.

The varieties were as fellows; Gangbori and Chalbori as a covered barley, Suwon 304 and Chalssalbori as a naked barley, Jinkwangbori as a malting barley, Algiwri and Malgiwri as an oat variety, and Chilbohomil and Chunchuhomil as a rye variety.

To prepare the fractions of various particle sizes, the air dried cereals were ground in a Tecator Cyclotec sample mill (Sweden) with a 0.5㎜ screen, then dried in an oven at 60℃ for 3 days. Oven-dried samples were sequentially sieved to collect the fractions of various particle sizes with passing through the 100 mesh >, 100-140 mesh, 140-200 mesh, and 200 mesh < screen, respectively.

On the other hand, to obtain the various milling recovery (weight basis) samples, grains were pearled in a laboratory-scale mill (Satake, Japan) by controlling the milling time to remove 10～70% of the original grain weight in 10% intervals.

The Hunter color values such as L (lightness), a (redness), and b (yellowness) were quantified by using color & color difference meter (Minolta Chromameter CR-200, Japan) which had adjusted with a standard white plate (L=97.38, a=-0.02, b=1.66).

The contents of β-glucans were analyzed according to the method of McCleary (McCleary et al., 1985; 1991) with a Megazyme kit (Ireland).

The procedures are as followers ; Milled flours were weighed 0.5 g, and add the 1.0*ml* of 50% ethanol, 5.0*ml* of 20mM sodium phosphate buffer (pH 6.5) then stir on a vortex mixer. Immediately after mixing, the sample tubes were incubated in a boiling water bath for two minutes and vigorously stir them on a vortex mixer. Heat the tubes for three minutes in the water bath and cool down about 40℃, and add 0.2㎖ lichenase (10 U), and incubate at 40℃ for one hour. After incubation, adjust the volume to 30.0㎖, then filter through a Whatman No. 41 filter paper. After filtering, transfer the 0.1㎖ of filtrate to test tubes and add the 0.1㎖ of 50 mM acetate buffer (pH 4.0) to the blank, while to the other two add 0.1㎖ of β-glucosidase (0.2 U) in 50 mM acetate buffer (pH 4.0). Incubate the tubes at 40℃ for 15 min. then add 3㎖ of glucose oxidase/peroxidase (GOPOD) reagent to each tube and incubate the tubes at 40℃ for 20 min., and measured the absorbance at 510 ㎚.

The β-glucan contents were calculated using the equation : β-glucan (%, w/w) = $\Delta E \times (F/mg) \times 27$, where ΔE represents the absorbance difference after β-glucosidase treatment-blank absorbance; F represents the factor for converson of absorbance values of 100㎍ of glucose; ㎎ represents the weight of sample, respectively.

RESULTS AND DISCUSSION

β-glucan contents in various particle sizes

Table 1 shows the β-glucan contents of winter cereals according to various particle sizes.

Obtained flours which have screened with various sieves were differed in their average contents of β-glucans, and the coarse fraction had higher contents of β-glucan than finely milled fractions. It has been reported that the brans of nonwaxy (hulled) and waxy (hull-less) barley contained the highest content of ash, free lipids, protein, and β-glucans but the lowest content of starch (Klamczynski & Czuchajowska, 1999; Zheng et al., 2000).

Kiryluk *et al.* (2000) have shown that as increasing the yields of flours and grits in hull-less barley, the β-glucan contents were increased and chemical components in the fine flours were lower than the coarse flours.

However, in this study, the β-glucan contents in the raw flours of every cereals were higher than those of their brans, and the highest β-glucan contents of every cereals were observed at 100 mesh > or 100-140 mesh fractions except the Chalssalbori fractions which showed their the higest β-glucan contents (12.9%) in 140-200 mesh fraction.

It has been reported that the major dietary fiber of rye is arabinoxylan, of which 60-70% is water unextractable, mixed-linked (1-3),(1-4)-β-D-glucan and cellulose. Nilsson *et al.* (1996) revealed varying substitution patterns for arabinoxylanst with ^{1}H-NMR spectroscopy and glucose residues in the 4M potassium hydroxide extracts were essentially originated from mixed-linked β-glucan. In this experiment, however, the milling process of oat grouts were very difficult because they producted a lots of breakage groats and sticky flours during the milling. As shown in Table 1, β-glucan contents of oat flour were especially higher in 100 mesh > flour than other winter cereals.

It was reported that high β-glucan contents in the oat groat were associated with higher bran yields, although the groat breakage was correlated with bran yield and with groat β-glucan concentration (Doehlert & McMullen, 2000). Nilsson (1997) had shown that the short and bran had higher concentrations of ash, crude protein, crude fat, lignans and dietary fiber. For this reason, obtained results in this experiment suggested that the β-glucan is located mainly in the cell wall of endosperm, and the bran yield and groat breakage from oat grains are closely related to their hardness, and sticky flours are largely attributed to groat composition of β-glucan and oil concentration.

Table 1. β-glucan contents of winter cereals according to the various particle sizes (unit : %)

Particle size (mesh)	Hulled barley		Hull-less barley			Malting barley	Oat		Rye	
	Gang-bori	Olbori	Chal-bori	Suwon 304	Chalssal-bori	Jinkwang-bori	Algiwri	Malgiwri	Chilbo-homil	Chunchu-homil
Raw flour	5.8	5.4	5.6	5.5	3.5	4.6	4.5	5.2	2.7	2.4
Bra	2.3	3.3	2.5	3.1	3.0	3.0	3.3	2.9	2.2	2.3
100 >	9.1	9.9	9.3	11.4	10.0	6.7	9.8	11.4	3.4	3.1
100-140	5.7	11.4	9.1	5.8	12.5	4.8	3.9	4.2	2.2	2.7
140-200	1.7	4.7	2.8	2.0	12.9	1.0	2.3	3.5	0.6	0.8
200 <	1.0	1.4	1.0	1.3	1.8	0.9	1.5	3.2	0.9	0.6

β-glucan contents according to milling recoveries

Fig. 1. shows the β-glucan contents of barley and rye according to various milling recoveries.

The β-glucan content in raw flour of Chalbori (hulled waxy barley) was 5.6%, and the highest β-glucan content (6.7%) was observed in the 50% milled grains.

As compared with the β-glucan content of Chalbori among the various milling recoveries, the β-glucan was distributed more evenly throughout the endosperm but β-glucan content in the bran of Chalbori was only 1.5%.

Bhatty (1997) reported that a 70% pearl yield of five registered cultivars of hull-less barley (HB) was devoid of the grain's outer coverings, including the aleurone and subaleurone layers, therefore, the balance of 30% constitutes true bran in HB. Doehlert & McMullen (2000) were analyzed for β-glucan distribution within HB grain and obtained the results that the β-glucan and acid-extract viscosity were very low in the outermost 20% of the kernel.

However, β-glucan content of Chalssalbori (hull-less waxy barley) was the highest in the subaleurone region (8.2%) and declined slightly toward inner layers of grain. This results suggest that β-glucan distribution between high (Chalbori) and low β-glucan barley

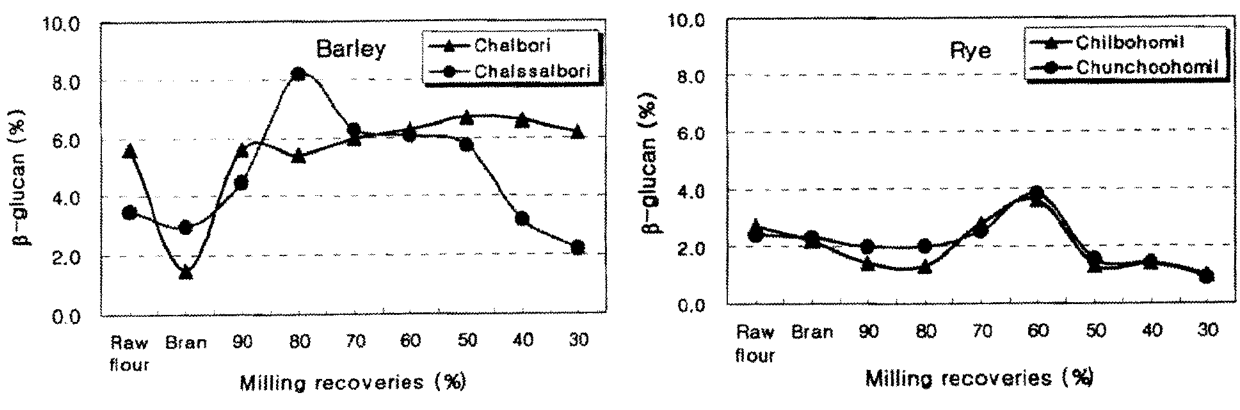

Fig. 1. β-glucan contents of barley and rye according to the various milling recoveries.

Table 2. Relationship between β ,-glucan contents and Huter color values of barley, oat and rye

Hunter color value	Barley	Oat	Rye
L	β-glucan(%) = -540.8+13.9L−0.09L^2 (R^2 = 0.679**)	NS[†]	β-glucan(%) = -149.6+4.08L−0.03L^2 (R^2 = 0.703**)
a	NS	NS	β-glucan(%) = 2.04−3.72a−253a^2 (R2 = 0.881**)
b	β-glucan(%) = -36.6+7.73b−0.33b^2 (R^2 = 0.762 **)	β-glucan(%) = 42.7−6.65b−0.28b^2 (R^2 = 0.891**)	β-glucan(%) = -12.7+2.8b−0.13b^2 (R^2 = 0.544*)

*, ** : Significant at 5% and 1% levels, respectively

[†]NS : Not significant.

(Chalssalbori) may explain the difference in milling performance of barley.

On the other hand, β-glucan contents of two rye varieties (Chilbohomil, Chunchoohomil) were lower than those of two waxy barley varieties, and the higest β-glucan contents were observed at the 60% milling recoveries. Therefore, it was considered that the true bran layer is constituted approximately 30-40% in rye grains.

β-glucan and color characteristics

Fig. 2. shows the Hunter values of winter cereals according to various particle sizes and milling recoveries.

In all winter cereals, the L-values (lightness) of raw flours were higher than those of brans, and barley varieties were higher than oat and rye varieties. As the particle sizes and milling recovery ratios were decreased, the L-value were increased. However, the particle size of flours were more affected the L-values of cereals than milling recovery ratio. The a-values (redness) in brans of every winter cereals were higher than those of every particle size flours and every milling ratio fractions. While the particle sizes and milling recovery ratios were decreased, the a-value of every particle size flours were decreased, but the values of every milling ratio fractions were slightly increased, and these tendency were observed in the b-values (yellowness) of various particle size of cereal flours, however, the b-values of every milling fractions showed no differences.

Table 2 shows the relationship between β-glucan contents and the Huter color values of barley, oat and rye. As shown in Table 2, the L and b-value of barley, the b-value of oat, and L, a, b-value of rye have the significant relationship with the β-glucan contents, respectively. This results represent the fact that β-glucans affected the color of the flours and pounded grains of winter cereals.

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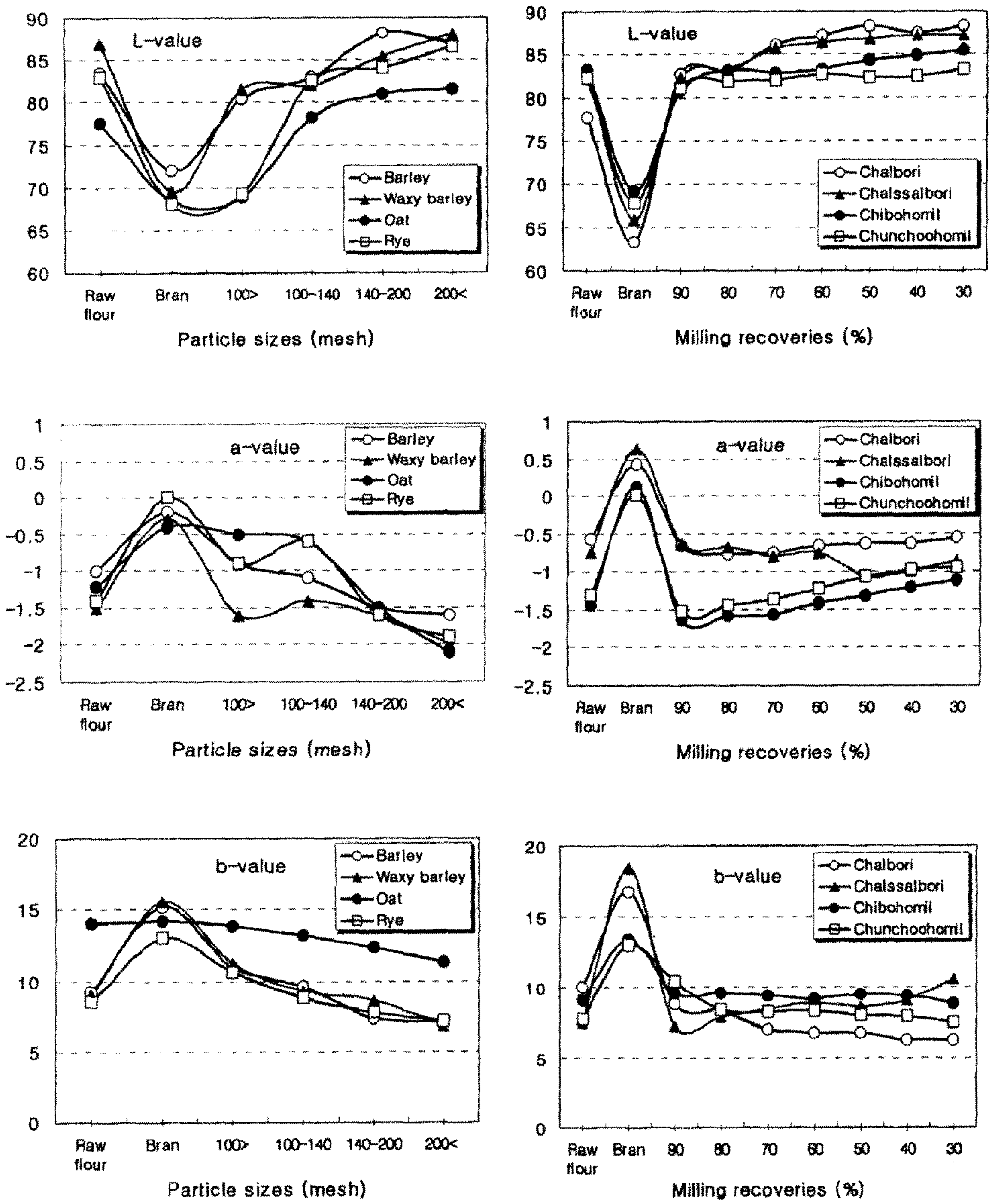

Fig. 2. Comparison on Hunter color values of winter cereals according to the various particle sizes and milling recoveries. (Barley : Gangbori, Waxy barley : Chalssalbori, Oat : Algiwri, Rye : Chilbohomil).

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(Recived 2001. 9.1)
(Accepted 2001.12.1)