Characteristics of biochemical markers and quality parameters using whole wheat flours in Korean wheat cultivars and lines

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ABSTRACT

The application of biochemical markers and small-sample methods, using whole-wheat flours, for screening in early generations of the Korean wheat breeding system is investigated. 74 Korean wheat genotypes, including cultivars, local breeding lines and experimental lines, were analyzed. Seed storage protein and amylose content of grains were evaluated. Biochemical makers, including granule bound starch synthase (GBSS), high molecular weight glutenin subunits (HMW-GS) and friabilin were also evaluated by using one-dimensional sodium dodecyl sulfate-polyacrylamide gel electrophoresis with a single kernel. The small-sample methods, including modified SDS-sedimentation test (MST), micro-alkaline water retention capacity (AWRC) and whole-wheat flour swelling volume (WSV) were also tested in this study. Protein content, MST and AWRC was 11.0-15.8%, 2.7-26.2 ml and 71.9-109.7%, respectively. Apparent and total amylose content and WSV was 20.6-25.0%, 26.1-32.4% and 9.0-16.9 ml, respectively. There were highly significant correlations between MST and AWRC ($r = 0.592$, $P < 0.001$), but Korean wheats showed no significant difference in protein content, amylose content using small-sample methods. For the biochemical markers, Korean wheats contained all three GBSS encoded by *Wx* loci, except for Suwon 252. Korean wheats showed the high frequency (58.1%) of 1Dx2.2 + 1Dy12 subunits of HMW-GS. Friabilin band was present in 46 lines (62.2%) and absent in 28 lines (37.8%). Friabilin-absent lines showed the higher MST (14.9 ml) and AWRC (92.1%) value than friabilin–present lines (8.5 ml and 82.4%, respectively).

INTRODUCTION

Korean wheat cultivars generally have high grain yield, early maturation, are semi-dwarf and have a moderate vernalization requirement. Quality improvement has recently received more attention by wheat breeders than ever before in Korea. Although the accurate evaluation of seed characteristics in early-generations is very important to improve end-use quality of wheat, there is little information about seed characteristics related to end-use quality in Korean wheat. This study is aimed at the evaluation of biochemical markers with a single kernel and whole-wheat flours, using small-sample methods, for rapid screening of wheat lines of potential use in quality improvement in Korean wheat breeding programs.

MATERIALS AND METHODS

Seed samples used in this study include 22 culitivars, 8 local breeding lines and 44 experimental lines were selected from Suwon and Milyang. Protein, amylase content, MST, AWRC and WSV were determined by the procedures of AACC 46-30, Morrison & Bernard (1983) with a prime starch, Dick & Quick (1983), Kitterman & Rubenthaler (1971) and Crosbie & Lambe (1993), respectively.

For the analysis of the HMW-GS and to extract total proteins with a single kernel, one-quarter of the single kernel, excluding the embryo, was excised. The remnant kernel was used for analysis of friabilin and the extraction of starch granule proteins, using the procedures of South and Morrison (1990). The analysis of friabilin was performed using non-gradient, discontinuous SDS-PAGE and resolving gels were 13.5% with 2.6% PDA crosslinker and included 10% (v/v) glycerol replacement of distilled water to reduce diffusion. The preparation of GBSS from isolated starch granules was based on the procedure described by Seo *et al*. (1998). One-dimensional SDS-PAGE analysis of GBSS was performed by 17% resolving gel and detected with silver stain.

RESULTS AND DISCUSSION

Characteristics of Whole-Wheat Flour

Protein contents ranged from 11.0 to 15.8%. Recently developed cultivars, Keumkang (15.7%) and Joeun (15.2%), showed higher protein content than other cultivars. Protein content of local breeding lines and experimental lines was 12.3-15.7% and 12.6-15.8%, respectively. Amylose

content was 26.1-32.4% in wheat cultivars, 27.7-31.1% in local breeding lines and 27.6-31.8% in experimental lines. In characteristics of whole-wheat flour, WSV was 9.0-16.3 ml in wheat cultivars, 11.3-15.1 ml in local breeding lines and 9.0-16.9 ml in experimental lines. MST volume was 3.1-26.2 ml in wheat cultivars and 3.1-25.1 ml in experimental lines. Local breeding lines showed narrow and lower MST volume (4.2-9.0 ml) than other Korean wheats. AWRC was 78.3-109.7% in wheat cultivars, 75.8-91.0% in local breeding lines and 71.9-106.7% in experimental lines.

Namhae, Ol, Olgeuru and Uri could be suitable for noodle-making because they have lower protein content (< 12.0%) and higher WSV (> 14.8 ml) than other cultivars. Although several lines of local breeding and experimental lines, including Chungnamjaerae, Suwon268 and Milyang12, showed high WSV (> 15.1 ml), protein contents of these lines were higher than the Korean wheat cultivars (Namhae, Ol, Olgeuru and Uri). Gobun, Keumkang and Tapdong can be used for bread-baking because these cultivars showed higher protein content (> 13.6%) and MST (> 21.9 ml) than other cultivars and lines. Milyang 10 showed lower AWRC (< 72.7%) than other cultivars and lines but protein content was 15.2%.

Biochemical Markers in Korean wheats

The Korean wheats were divided into 15 different groups on the basis of their HMW-GS composition. Three alleles were identified at the *Glu-A1,* five at the *Glu-B1* loci and three at *Glu-D1* loci. The high frequency (85.1%) of null allele on *Glu-A1* loci was found. The subunits of 1Bx7 + 1By8 were present at high frequency (74.3%) in *Glu-B1* loci. Low frequency (10.8%) of 1Dx5 + 1Dy10 subunits and the high frequency (31.1%) of 1Dx2 + 1Dy12 subunits were found. Korean wheats particularly showed a high frequency (58.1%) of 1Dx2.2 + 1Dy12 subunits. The introduction of 1Ax subunits, 1Ax1 or 1Ax2*, and 1Dx5 + 1Dy10 subunits should be seriously considered in Korean wheat breeding programs for better bread-baking quality.

The friabilin band was present in 46 lines (62.2%). In this study, Suwon 252 was the only line that had a null allele on the *Wx-A1* locus while other lines contained all three GBSS isoforms in Korean wheat cultivars and lines. The result of friabilin, using three-quarters and HMW-GS compositions using one-quarter a single kernel, presented no problem in evaluating wheat cultivars and lines. Therefore, to utilize this method in Korean wheat breeding programs, the improvement of the analytic method of HMW-GS and the method of GBSS and friabilin with a single kernel will be accomplished in our laboratory. For genetic diversity in relation to amylose content and improvement of noodle quality in Korean wheat, it is first necessary to obtain the amylose-free and reduced-amylose wheat lines with genetic manipulation through recombination between Korean wheats lines and null lines on *Wx* loci.

Relationships Between Whole-Wheat Flour Properties and Biochemical Markers

There were highly significant correlations between MST and AWRC ($r = 0.592$, $P < 0.01$), but these characteristics had no significant correlations with protein content in this study. The relationships among protein content, MST and AWRC found in this study is in agreement with previous reports (Ayoub *et al*., 1993, Bassett *et al*. 1989, Gaines 1991). These results might be influenced by the high protein content of whole-wheat flours in Korean wheat cultivars and lines. Korean wheats also had narrow variation in amylose content influenced by genetic variation of GBSS. This property of Korean wheats might suggest there is no significant correlation between amylose content and WSV.

There was no difference in the protein content between 2.2-present and absent lines and friabilin-present and absent lines. Friabilin-absent lines showed the higher MST value (14.9ml) than friabilins-present lines (8.5ml), but there was no difference between 2.2- present and absent lines. Difference in the AWRC values between 2.2-present and absent lines was not found, but friabilin-absent lines showed a higher AWRC value (92.1%) than that of friabilin-present lines (82.4%). Both 2.2-absent and friabilin-absent lines showed the higher MST and AWRC values (16.3ml and 90.5%) than those of other lines. There was a high co-occurrence (36.5%) of 1Dx2.2 + 1Dy12 subunits of HMW-GS and friabilin. The concentrated research of biochemical-genetic relationships, the high frequency of co-occurrence of 1Dx2.2 + 1Dy12 subunits of HMW-GS and friabilin in Korean wheat cultivars should be studied.

CONCLUSION

The results of biochemical markers with single kernel, HMW-GS, GBSS and friabilin, and small-sample methods, MST, AWRC and WSV, might provide useful tools to characterize wheat lines and contribute to the identification and selection of breeding lines in early generations of wheat breeding programs. The introduction of 1Dx5 +

1Dy10 subunits of HMW-GS, the increase of the flour protein content and overcoming narrow genetic diversity in amylose content with genetic recombination using other genetic resources carrying null GBSS isoforms, should be considered for the future improvement of end-use qualities of Korean wheat cultivars.

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