Bread-making Quality of a Near-isogenic Line with Specific Low Molecular Weight Glutenin Components

Kanenori Takata*, Hiroaki Yamauchi, Zenta Nishio and Tatsuo Kuwabara

Hokkaido National Agricultural Experiment Station (HNAES), Shinseii, Memuro, Hokkaido 082-0071, Japan

Key Word: *Triticum aestivum* L., low molecular weight glutenin, bread-making quality, near-isogenic line.

The gluten protein consists of aggregates of high molecular weight glutenin (HMWG), low molecular weight glutenin (LMWG), and gliadin. HMWG subunits are coded by genes at *Glu-A1*, *Glu-B1*, and *Glu-D1* on the long arm of chromosomes 1A, 1B, and 1D and associated with bread-making quality (Payne et al. 1979, 1980). Gliadins are controlled by genes at *Gli-1* and *Gli-2*, located on the short arms of both homologous groups 1 and 6 chromosomes (Wringley and Shepherd 1973). The genes coding for LMWG subunits are encoded by genes at loci designated *Glul-3* located on the short arm of chromosomes of the homologous group 1 (Jackson et al. 1983). *Glul-3* loci are linked closely to *Gli-1* loci (Payne et al. 1984). The specific gliadin and LMWG are also associated with bread-making quality (Pogna et al. 1982, Gupta et al. 1989). However, it has been difficult to identify the effect of these protein components in many cultivars because their genetic backgrounds and protein contents are different.

Canada Western Extra-Strong Red Spring (CWESRS) wheat, which has extremely strong dough properties, shows unique properties. First, its dough is excellent for frozen-dough baking (Inoue and Bushuk 1992). Second, the sprouting-damaged wheat resists decreasing dough strength (Bushuk and Lukow 1987). Third, the blending flour has a high bread-making quality (Bushuk 1980). For the improvement of flour quality in Japanese wheat, it would be useful to detect the protein components related to these properties and introduce them into Japanese wheat cultivars. In this study, we estimated the bread-making quality in a near-isogenic line (NIL) introducing specific LMWG components from the CWESRS wheat cultivar Glenlea. The substituted LMWG components showed extremely strong effects on bread-making quality.

Plant materials

The Japanese wheat cultivar Harunoakebono (HMWG subunits 2*, 7 + 9, 5 + 10) was crossed with Glenlea (HMWG subunits 2*, 7 + 8, 5 + 10). The progenies were backcrossed five times with Harunoakebono. The protein components of backcrossed seeds were checked by SDS-PAGE according to Hou and Bushuk (1995). LMWG have mobilities similar to gliadin on SDS-PAGE. Gliadins were removed with 60% ethanol solution and glutenin proteins were prepared by sequential acetone precipitation. LMWG components were distinguished from gliadin components. BC3 generation was checked for the homozygous genotype of the glutenin and gliadin components by SDS-PAGE and acid-PAGE (Bushuk and Zillman 1978), respectively. NIL, Harunoakebono, and Glenlea were cultivated in 4 m-long rows, each of which was 72 cm apart, at the HNAES in 1999.

Flour-quality tests

Grain samples were milled on a Brabender Jr. test mill (Brabender Inc., Germany). Tests were conducted according to Takata et al. (2000b) to evaluate: flour protein content, SDS-sedimentation volume, mixing properties (peak time and breakdown), extension (breaking force and breaking deformation), and baking. Flour protein content was measured by near-infrared spectroscopy with an Inframatic 8120 (PerCon, Germany). Mixing properties were estimated by an improved 35 g Swanson head pin-type mixer (National Mfg., U.S.A.). The peak time (min) was the mixing time at maximum electric current, and the breakdown (A) represented the differential of the electric current between the peak time and 2 minutes after the peak time. The extensibility of the dough was measured with a Rheomer (model RE33005) (Yamaden Inc., Japan). The breaking force showed the force (N) to the breaking point of dough, and the breaking deformation represented the moving length (mm) up to the breaking point of the dough. A baking test was performed by the no-time straight method.

Electrophoresis patterns

The SDS-PAGE patterns of NIL, Harunoakebono, and Glenlea are shown in Fig. 1. NIL and the recurrent parent, Harunoakebono, had the same HMWG and LMWG except for the LMWG components substituted between Harunoakebono and Glenlea, and they are indicated with the arrows. In this study, an easily discerned band was used as a marker.
of LMWG components from Glenlea. This specific LMWG band is shown by the larger arrow in Fig. 1, which was estimated as 44 kDa in molecular weight.

Estimation of bread-making quality

The quality test of the donor cultivar Glenlea was not performed because of pre-harvest sprouting damage. The protein contents of NIL and Harunoakebono were 13.4% and 13.5%, respectively (Fig. 2). It was suggested that the influence of the protein content, which is greatly associated with bread-making quality, was not reflected in the flour properties of NIL and Harunoakebono. The SDS-sedimentation volume of NIL (60ml) showed a higher value than that of Harunoakebono (49ml) (Fig. 2). The SDS-sedimentation volume showed a high correlation to the loaf volume and the dough strength (Axford et al. 1979, Preston et al. 1982). The high SDS-sedimentation volume predicted the strong dough property and the high specific loaf volume. The mixing characteristics were related to good bread-making quality, which generally means adequately long mixing time and superior mixing tolerance. The peak time of NIL (4.0min) was longer than that of Harunoakebono (2.6 min) (Fig. 3). The peak time of Harunoakebono showed a similar value to that of commercial strong flour (data not shown). NIL showed the flour property of extra-strong wheat, which had a greater mixing-time requirement than strong flour. The breakdown of NIL (0.10A) showed a smaller value than that of Harunoakebono (0.12A) (Fig. 3). The breakdown indicates dough weakness after the peak time, and the smaller value means that the dough has strong resistance to weakness. These results suggested that the substituted LMWG components were associated with strong mixing characteristics. The results of the extensibility test (breaking force and breaking deformation) are presented in Fig. 4. The breaking force of NIL (3.0N) gave a larger value than that of
Harunoakebono (2.2N). Our previous results (Takata et al. 2000c) showed that the higher values of the breaking force were well correlated to a higher specific loaf volume. Then, this breaking force value predicted a specific high loaf volume. In the baking test, the mixing time of NIL (5.8 min) was much longer than that of Harunoakebono (3.3 min). The NIL required a much longer mixing time as compared with Harunoakebono (Fig. 5). The specific loaf volume of NIL (6.38 ml/g) was larger than that of Harunoakebono (5.48 ml/g) (Fig. 5). It was considered that the NIL has a high specific loaf volume as a result of the LMWG, which gave the strong dough property. The LMWG and HMWG subunits have additive effects on bread-making quality (Gupta et al. 1989, Benedettelli et al. 1992). Gupta et al. (1994) reported that the Glu-B1 allele of HMWG had a larger effect on dough strength than LMWG. Perron et al. (1998) reported that the LMWG components from semi-dwarf Glenlea were associated with dough-strength characteristics, but only when HMWG subunits 7+8 were present. Ng et al. (1989) observed that the 1Bx subunit 7 of HMWG derived from Glenlea was overproduced, increasing dough strength. However, the specific LMWG components from Glenlea showed extremely strong dough characteristics without HMWG subunits 7+8. Wesley et al. (1999) demonstrated that a gliadin component linked to LMWG 52 (Glu-B3f) had a stronger effect than HMWG subunits 17+18, which gave the largest effect on bread-making quality at the Glu-B1 allele. It is reasonable to suppose that the specific LMWG components showed larger dough strength than HMWG subunits, except for subunits 5+10 at Glu-D1 allele, as compared with our previous results (Takata et al., 2000b). For example, the breaking force value of subunits 5+10 was 0.78N larger than subunits 2+12 at Glu-D1 allele, and that of this LMWG was 0.80N larger than subunits 5+10 in the same genetic background of Harunoakebono. The difference in the extent of contribution to bread-making quality between HMWG subunits 5+10 and those of LMWG components remains to be clarified. It seemed that the specific LMWG components had an equivalent effect on dough property in comparison with 5+10 subunits. The introduction of the specific LMWG components to Japanese wheat cultivars could strengthen their dough properties and thus improve their bread-making quality.

**Literature Cited**


