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Rheological and Milling Characteristics of Naked and Covered Barley Varieties

by
Hong-Sik Cheigh, Harry E. Snyder* and Tai-wan Kwon
Food Resources Laboratory, Korea Institute of Science and Technology
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겉보리와 쌀보리의 제분특성 및 점조성

최흥식, H.E. 스나이더* 권태완
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요　　약

일정한 제분 조건하에서 쌀보리의 제분수율은 겉보리의 경우보다 약 10% 높았으나, 제품속의 회분 함량은 오히려 낮았다. 그리고 쌀보리 가루의 아미로그람은 겉보리가루보다 높은 점성을 보였다. 보리가루와 밀가루의 10 : 90 및 30 : 70 혼합물로 부터 만든 반죽의 화리노그람에서는 보리가루 함량이 증가함에 따라서 제빵품질이 감퇴됨을 살폈다. 또, 제빵비교 시험에서도 쌀보리가루의 경우 겉보리가루보다 안전성이 높았고, 탄력이 좋았으며, 조직이 튼튼하였다.

INTRODUCTION

This research was done to gain more information on barley varieties which would be helpful in producing a composite flour. We were particularly interested in the milling yields obtained with different naked and covered barley varieties and in the amylograph and farinograph behavior of the barley flours produced.

Previous research on barley milling include Kim's studies on the optimum conditions for tempering barley in relation to milling yield and the optimum conditions for milling barley mixed with wheat[1]. Also, Pomeranz *et al*[9] did experiments on test mill yields of several barley varieties and composition of the flour streams. The protein and carbohydrate contents of 22 varieties of barley were reported by Lee and Park[5].

The rheology of barley flour was investigated by Kim *et al*[3] who studied Sedohadaga naked barley flour after polishing and milling. Such flour was found to have much higher viscosity in the amylograph than wheat flour. Also, the amylograph behavior of barley starch was studied by Goering *et al*[4]. They found the barley starch generally had much higher viscosity after cooking than wheat starch. To our knowledge no previous studies have been published of the farinograph behavior of wheat-barley flour mixtures.

METHODS AND MATERIALS

Covered barley varieties tested were Boohung and Suwon #18 obtained from the National Agricultural

*Visiting Professor from Department of Food Technology, Iowa State University, Ames, Iowa, U.S.A.

Products Inspection Office, Seoul. The naked barley varieties were Sedohadaga and Kwangsung supplied by the Research Section, Office of Rural Development, Kwangju. All barley samples were from the 1974 crop. The wheat used was hard red winter wheat.

A Buhler test mill was used with three break rolls and three reduction rolls followed by an impact finisher. The mill streams and screen sizes are shown in Fig. 1. The rate of feed to the mill was 2.5 kg for 48 min., and a total of 2.5 kg of barley was milled for each variety. The yield of flour in each mill stream was determined by collecting and weighing.

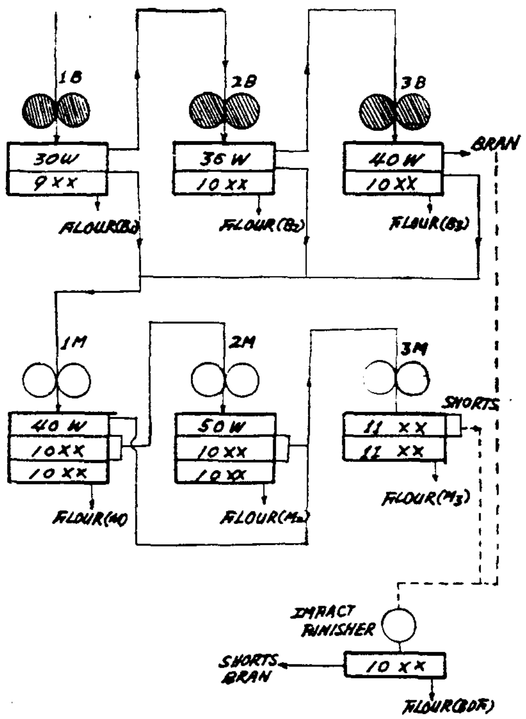

Fig. 1. Flow diagram and screen sizes for Buhler test mill.

Covered barley was tempered prior to milling to 15% moisture and held for 24 hrs, and naked barley was tempered to 14% and held for 48 hrs. Temperature during equilibration was 20°C. These conditions were chosen based on the work of Kim[1].

Proximate analyses of moisture, ash and protein were done following AACC standard procedures[2]. Proximate analyses were made on the four barley varieties prior to milling(the grain was ground in a wiley mill) and on the straight flours obtained from each of the barleys.

The amylograms were obtained with a Brabender Amylograph using 450 ml water and sufficient straight barley flour to give either 8.6 or 7.0% solids. Temperature was increased at a rate of 1.5°/min up to 93°. The temperature was held at 93° for 8 min. and then decreased to 68° at a rate of 0.75°/min.

The farinograms were obtained with a Brabender Farinograph using the large bowl(300 g of flour) and the constant flour weight method[2]. The velorimeter values were calculated based on the Brabender Procedure.

RESULTS AND DISCUSSION

In Table 1 are data on the proximate composition of the four barley varieties used in this study. The ash is higher for the covered barley than for naked barley and weight per unit volume is lower for covered barley compared to naked barley. Otherwise there is little difference between the two types of barley or between the two varieties within each type.

Table 1. Characteristics of covered barleys and naked barleys (whole grain) used in the study

	Moisture (%)	Ash¹ (%)	Protein¹ (%)	Weight g/l
Covered barley				
Boohung	10.2	2.50	13.0	610
Suwon #18	10.5	2.45	11.9	604
Naked barley				
Sedohadaga	11.4	1.85	10.2	804
Kwangsung	11.5	1.92	10.6	808

1 Calculated on 14% moisture basis.

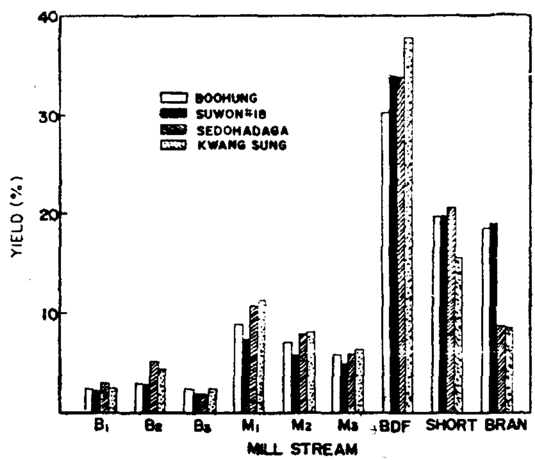

Fig. 2. Yields of milled barley varieties in each mill stream.

After milling, the yield for each mill stream is shown in Fig. 2. In each mill stream, except for B3, the yield of flour from naked varieties is greater than from covered barley. This accounts for the greater extraction rate with naked barley compared to covered barley. The portion of the grain going to bran is consequently greater for covered barley than for naked barley, whereas the portion of the two types going to shorts is about the same. The greater quantity of shorts for Sedohadaga in comparison to Kwangsung is probably related to the inverse relationship existing in the BDF stream. It is not certain whether this is a real difference between these two naked barley varieties. The milling yields from this study cannot be compared directly with results of Pomeranz *et al* [9], because they used a constant extraction rate of 65% to prepare patent flours.

The test milling of barley gives quite different proportions in the mill streams than the milling of wheat. In general wheat would yield larger quantities of flour from the first two break rolls and much larger quantities of flour from the first two reduction rolls. Also, the wheat flour from the BDF stream would only be 7 to 8% compared with 30 to 37% for barley. One of the reasons for these differences is an aggregation of barley flour that causes it to be carried over to the impact finisher. Wheat flour does not aggregate as readily as barley flour.

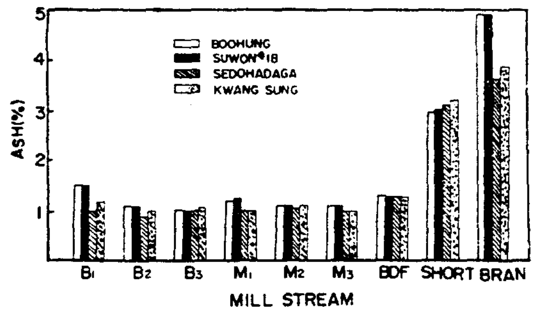

Fig. 3. Ash content of milled barley varieties in each mill stream.

The ash contents of the various barley mill streams can be compared in Fig. 3. The first break rolls and first reduction rolls produce flour with higher ash content for covered barley than for naked barley. Also, the bran fraction is higher in ash for covered barley than for naked barley. Otherwise, there is relatively little difference in ash content between covered barley and naked barley. The two different varieties of each type of barley show very little difference in ash content of the various mill streams.

Table. 2. Extraction rate and proximate chemical composition of barley flours

	Extraction rate (%)	Moisture (%)	Protein[1] (%)	Ash[1] (%)	Crude fat[1] (%)
Boohung	61.2	9.0	12.9	1.19	1.90
Suwon #18	60.7	8.6	12.3	1.19	2.20
Sedohadaga	69.5	9.4	8.9	1.08	1.62
Kwangsung	74.3	9.5	9.5	1.09	1.70

1 Calculated on 14% moisture basis.

The mill streams B1, B2, B3, M1, M2, M3 and BDF were combined to make a straight flour for each of the four barley varieties. Data in Table 2 show the extraction rates and proximate composition for the four barley flours. The main differences are a higher extraction rate, a lower ash content and a lower fat content for naked barley compared to covered barley.

With the barley flour produced by test milling, we were interested in learning more about the rheological behavior of these flours in relation to baking. For this purpose, both amylograms and farinograms were obtained.

Fig. 4 shows the amylograms for the four barley straight flours and for wheat flour. At 8.6% solids, the viscosities for flours from the two naked barley varieties were much higher than for wheat or for covered barley. Consequently, amylograms were also obtained for Sedohadaga and Kwangsung varieties at 7% solids. The amylograms show viscosities for all flour pastes after cooling to 68°. Kim *et al*[3] reported on hot paste viscosities for Sedohadaga flour produced from barley that had first been polished. Using 50 g of flour and 450 ml of water they obtained higher viscosities for naked barled flour than for wheat flour, and the lowest of three different extraction flours had the highest viscosity. These data are difficult to compare directly with the viscosities found in our experiments, but the general concept of higher viscosities with naked barley flour than with wheat flour or covered barley flour seems valid from both sets of data. Goering *et al*[4] have shown that naked barley starch has higher viscosity than the starch from covered counterpart varieties.

Amylograms are commonly used to evaluate wheat that may have ben damaged and consequently has high amylolytic activity. Naked barley would probably be even more sensitive to such an evaluation because

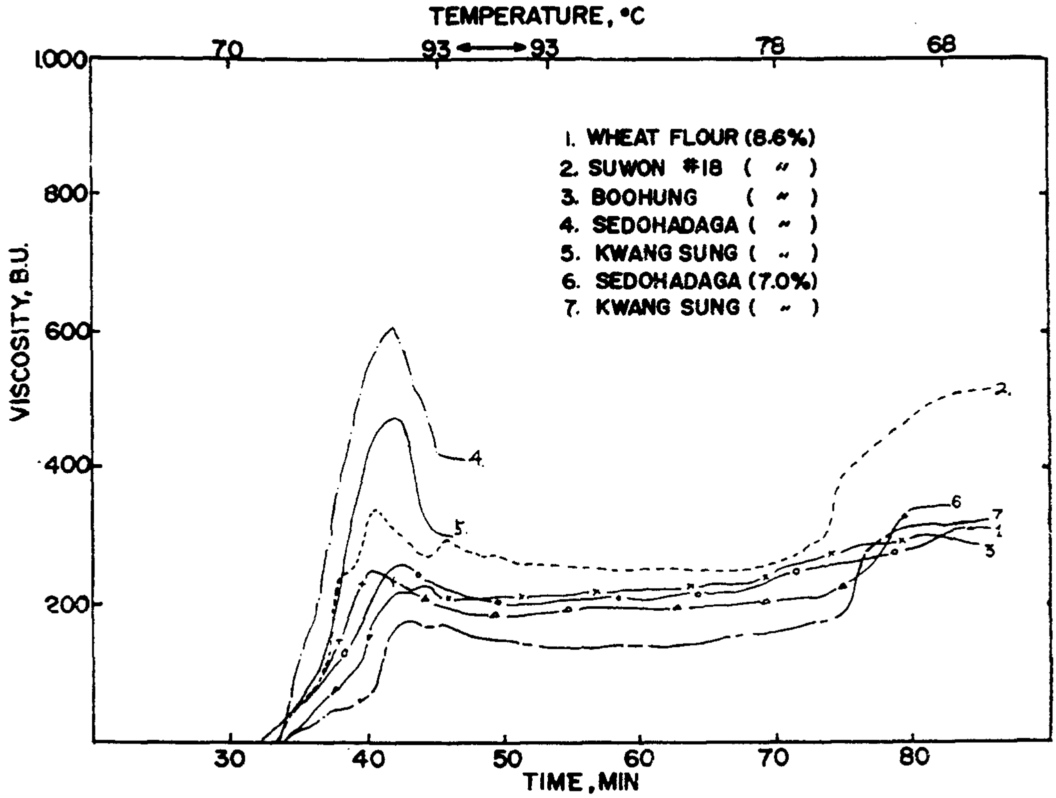

Fig. 4. Brabender amylograms for different barley varieties.

Table 3. Amylogram characteristics

	Solid level (%)	Gelatinization point (°C)	Temp. at maximum viscosity (°C)	Maximum viscosity (B.U.)	Viscosity at 93°C (B.U.)	Viscosity at 68°C (B.U.)
Wheat (1)	8.6	72	88	260	220	280
Boohung	8.6	73	85	250	210	320
Suwon #18	8.6	73	86	340	300	470
Sedohadaga	8.6	75	87	620	425	—
	7.0	75	87	220	200	340
Kwangsung	8.6	75	88	480	300	—
	7.0	75	87	170	165	320

(1) Hard winter wheat flour

Table. 4. Farinographic characteristics

	Absorption (%)	Developing time, min.	Stability min.	Elasticity B.U.	Weakening B.U.	Velorimeter value
Wheat(100)	62.8	2.7	6.3	100	45	75
Boohung (10)+Wheat(90)	66.4	6.0	1.2	82	84	65
Boohung(30)+Wheat(70)	69.8	5.0	1.0	73	140	58
Suwon #18(10)+Wheat(90)	66.5	5.3	1.3	89	71	67
Suwon #18(30)+Wheat(70)	70.3	4.8	1.2	78	123	59
Sedohadaga(10)+Wheat(90)	64.3	5.0	2.8	95	56	71
Sedohadaga(30)+Wheat(70)	67.3	4.3	1.8	89	81	63
Kwangsung(10)+Wheat(90)	64.2	5.2	2.0	95	57	68
Kwangsung(30)+Wheat(70)	69.1	4.0	1.6	87	87	60

of the high viscosity and the high amylolytic activity of sprouted barley.

Table 3 shows data from Fig. 4 on the gelatinization point and viscosity of the various flours. The gelatinization point does not vary widely among the barley flours or between wheat and barley flour, but is slightly higher for naked varieties than for covered barley flour. The temperature of maximum viscosity is slightly higher for naked barley flour than for wheat or regular barley flour, but the big difference is in the viscosities. At the temperature of maximum viscosity and at lower temperatures the naked barley varieties had higher viscosity than wheat flour or covered barley flour. Of the covered barleys, Suwon #18 had higher viscosity than Boohung at all temperatures.

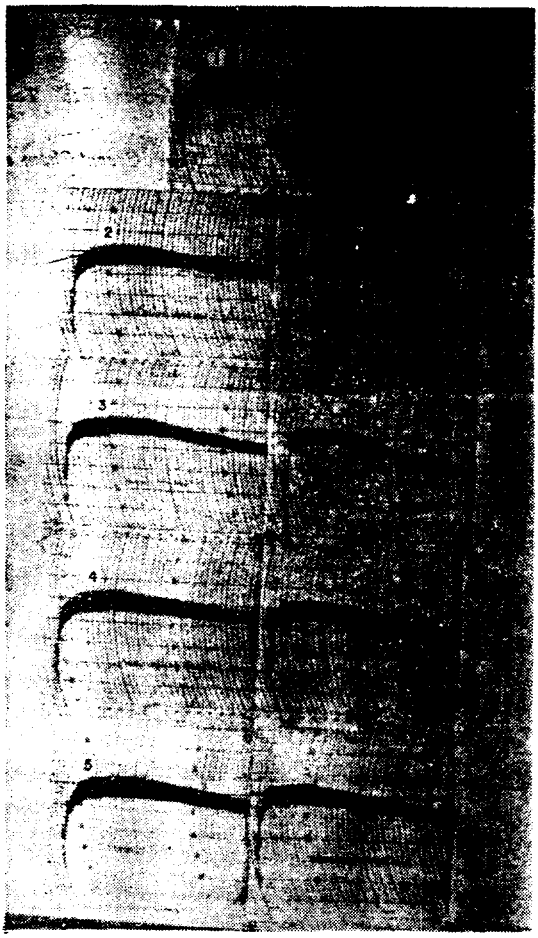

Fig. 5. Farinograms for wheat and wheat-barley mixtures. 1-hard red winter wheat, 2-wheat and Suwon #18, 3-wheat and Boohung, 4-wheat and Kwangsung, 5-wheat and Sedohadaga. Farinograms on the left for 90:10 wheat:barley mixtures and farinograms on the right for 70:30 wheat:barley mixtures.

For bread baking, the rheological behavior that is most meaningful is given by farinograms. We obtained farinograms for wheat flour and for the four barley varieties mixed in 10 : 90 and 30 : 70 proportions with wheat flour. Fig. 5 shows the data obtained, and Table 4 summarizes the values for key parameters taken from the farinograms. From the farinograms in Fig. 5, it is evident that addition of barley flour at 10% of the total causes an increased developing time, decreased stability and increased weakening, when compared to 100% wheat flour. The addition of 30% barley flour accentuates even more the changes seen with 10% barley flour. Comparing the addition of naked barley flour with the addition of covered barley flour, the stability is greater, the elasticity is greater and the weakening is much less with naked barley flour additions. These comparative results are true for both 10% and 30% additions of barley flour. Note that no dough improver such as sodium stearoyl lactylate (SSL) was used in the preparation of these barley-wheat flour doughs. The inclusion of SSL does improve the velorimeter value for doughs made from composite flours.

Water absorption is increased by barley flour substitution for part of the wheat flour, and water absorption is greater for 30% substitution of barley flour than for 10% substitution. Since weakening also was greatest with 30% substitution of barley flour, it was a possibility that weakening was related to the increased moisture content of doughs with 30% added barley. However, a comparison of weakening for 30% addition of Boohung barley flour and for 30% addition of Kwangsung naked barley flour (for which water absorptions were almost the same (69.8% and 69.1% respectively) shows the Boohung flour addition caused much greater weakening. Thus it is not likely that the additional water in the barley-wheat mixtures is responsible for the increased weakening.

Calculations of the velorimeter values show that naked barley flour additions generally give better bread baking properties than covered barley flour additions at the same quantity of added barley flour (although the differences between Suwon #18 and Kwangsung are slight).

SUMMARY

Milling yields from naked barley varieties were found to be approximately 10% greater with a constant milling rate than yields from covered barley varieties. Also, the ash content of flour from naked barley varieties is less than from covered barley. Amylograms from barley flours showed higher viscosity for the naked varieties than for covered varieties. Farinograms of doughs prepared from 10:90 and 30:70 barley: wheat flour mixtures indicated general deterioration of bread baking qualities with increasing ad... ns of barley flour. A comparison of bread baking qualities between naked and covered barley flours sh(greater stab- ty, greater .lasticity, and less weak...ing with naked barley flour than with covered barley flour.

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