KOREAN J. FOOD SCI. TECHNOL.
Vol. 10, No. 1 (1978)

Rheological and Baking Studies of Composite Flour from Wheat and Naked Barley

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(Received August 31, 1977)

밀—쌀보리 복합분의 물리적 성질 및 제빵 시험

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(1977년 8월 31일 수리)

Abstract

Barley (variety, Bangsa No. 6) was milled on a stone mill with 60% flour extraction. Rheological and baking properties of composites containing 5 and 10% of the barley flour with wheat flour (11.4% protein) were investigated. As the barley flour level was increased, amylograph paste viscosities increased at all reference points and farinograph stability decreased. However, no significant differences were noted in the proportional number measured with extensigraph with the various flours. Loaf volume and the staling rate of bread decreased and increased respectively as the barley flour level was increased.

Introduction

Over the past ten years wheat imports by Korea have increased rapidly to reach an annual total approaching two million tons in the years 1975 and 1976. The growing of a significant quantity of wheat in Korea appears to have little promise but barley production, especially of the naked type, has increased several fold and there is a good potential for a further considerable increase in this crop. If this increase materializes, a surplus of barley over present usage may exist in Korea.

The development of composite flour, an admixture of flours obtained from imported wheat and locally grown crops, in Korea, was initiated to limit the importation of wheat (and thus limit the expenditure of foreign exchange) and to extend the quantities of foods produced from wheat.[1-10] The results demonstrated[2,8] that among locally grown crops naked barley flour held promise for the partial substitution of wheat flour for breadmaking.

The purpose of this study was to investigate the physical dough properties and baking potential of composite flour containing wheat and naked barley and to examine the quality and staling rate of bread which was produced using such a flour.

Materials and Methods

Flours: Naked berley(variety of Bangsa #6), harvested in 1975, was obtained from the Chulanamdo branch of the National Seed Production and Distribution Office and milled to 60% extraction using a stone mill. The barley flour contained 8.9% protein (N× 6.25) and 1.10% ash on a 14% moisture basis (mb).

Composite flours were prepared by substituting commercial wheat flour (11.4% protein and 0.43% ash on a 14% mb) with barley flour at the 5 and 10% levels.

Pasting properties: Pasting properties of the flours (60g, db in 450ml distilled water) were investigated with the Brabender Amylograph.

The information obtained from the amylograph curve included initial pasting temperature, peak height, height at 95°C, 15min-hold height and setback. Definition of these terms was given previously.[11]

Physical dough properties: The farinograph and extensigraph were used to determine the physical dough properties of the various flour samples. For the farinograph studies, the 50g bowl with a 50g flour sample was used.[12] For the extensigraph tests, doughs were prepared by mixing 100g flour with 1.0% sodium chloride, 0.003% potassium bromate and a quantity of water as indicated by the farinograph absorption. The extensograms were obtained from the doughs which were allowed to rest for 45 min and 180 min at 30°C (78% RH). The proportional number was calculated by dividing the resistance to extension(cm) by the extensibility(cm) for both the 45 and 180 min rest periods.

Bread samples: Bread was made using a no-time dough procedure with a 25-min rest, a 50-min proof period at 40°C and a 20-min bake at 200°C.

The baking formula based on flour weight was as follows:

Flour	100%
Yeast	3.0%
Salt	2.0%
Shortening	3.0%
Sugar	5.0%
1-Cysteine. HCl	40ppm
Ascorbic acid	120 ppm
Potassium bromate	36ppm
Water	Variable

Aging of bread: Bread was cooled at room temperature for 2hr, then sliced and stored at 25°C in sealed containers to prevent moisture loss. At 0, 1, 2, 3 and 4 days, bread crumb was tested for firmness using a Texturometer(General Foods Corp., New York). The limiting modulus was obtained from bread which was stored at 4°C for 6days.

The values of E_0, E_1, E_2, E_3 and E_4, which represent the firmness of the bread crumb at 0, 1, 2, 3 and 4 days, respectively, were subjected to Avrami analysis to determine the rate constant and the Avrami exponent, as described previously.[13]

Results and Discussion

Data on the pasting properties of the wheat and naked barley flour, and composite flours are shown in Table 1. Barley flour showed a similar pasting temperature but higher paste viscosities at all reference points than wheat flour. Likewise, as expected, the paste viscosities of the composite flours were higher than wheat flour. No significant differences for the initial pasting temperature and the peak temperature were noticed among flour samples. These results indicate that the swelling of the starch in the wheat flour and in the composite flour follows the same pattern. The 10% barley containing flour showed a significantly higher setback value (heigh at 50°C) than other flour samples. The possible importance of such results to crumb firming will be discussed later.

Table 2 shows the farinograph data of the various flours. The composite flours decreased only the stability. These results are considerably different from those reported by Kwon *et al.*,[9] who reported that the substitution of wheat flour with naked barley flour at the 10% level significantly increased dough development time and absorption. These differences may be due to the different barley varieties and/or different flour extractions employed in both studies.

Table 3 shows the extensigraph data of the various flours. No significant differences were noted for the proportional numbers between wheat flour and the composite flours. The greater the proportional number, the shorter the dough.

Breads baked with wheat and composite flours are shown in Fig. 1 and the baking results are presented

Table 1. Amylograph data of wheat and wheat-naked barley flours

Flour	Initial Pasting Temp. (°C)	Peak Height (BU)	Height at 95°C (BU)	15 min Hold Height (BU)	Height at 50°C (BU)
100% Wheat(W)	61.0	525	350	235	630
100% Barley(B)	60.0	1060	1015	905	1410
95%W : 5%B	61.0	580	340	240	640
90%W : 10%B	61.5	595	445	260	690

Table 2. Farinograph data of wheat and wheat-naked barley flours

Flour	Absorption	Dough Development Time(min)	Stability(min)
100% Wheat(W)	59.3	5.0	10.5
95%W : 5% Barley	60.0	4.5	9.0
90%W : 10% Barley	59.6	4.5	8.0

Table 3. Extensigraph data of wheat and wheat-naked barley flours

Flour	Resistance to Extension(A) (cm)		Estensibility(B) (cm)		Proportional Number(A/B)	
	45min Rest	180min Rest	45min Rest	180min Rest	45min Rest	180min Rest
100% Wheat(W)	8.6	10.1	21.2	18.3	0.41	0.55
95%W : 5%Barley	7.9	9.8	21.0	19.1	0.38	0.51
90%W : 10%Barley	8.1	10.6	19.5	19.1	0.42	0.55

Table 4. Baking data on wheat and wheat-naked barley flours

Bread Produced from	Baking Absorption (%)	Specific Volume[a] (cc/g)	Crust Color[b]	Crumb[b]		
				Color	Grain	Texture
100% Wheat(W)	60.0	5.09	9.0	8.0	8.5	9.0
95%W : 5%Barley	60.0	4.91	9.0	7.0	8.0	8.5
90%W : 10%Barley	59.5	4.67	9.0	6.0	7.5	7.5

a : An average of eight loaves.
b : Values are based on a score of 1-10 with 10 being the best score.

Table 5. Data for Avrami analysis of bread stored at 25°C

Bread Produced from	Avrami Exponent (n)	Time Constant (days)
100% Wheat flour(W)	1.05	4.26
95%W : 5% Naked Barley flour	0.99	4.09
90%W : 10% Naked Barley flour	1.06	3.98

in Table 4. Specific volume and crumb charactaristics of bread became inferior as the amount of barley flour in the composite increased. These results were in agreement with the farinograph data that indicated weaker dough properties for the composite flours than for the wheat flour (Table 2). However, the baking test results showed that both the 5 and 10% barley-wheat composite flours could produce acceptable bread. The 10% barley containing bread reduced loaf volume(Table 4) and produced a crumb grain which was darker and less regular than the wheat bread but nevertheless was quite acceptable. The preliminary taste panel information indicated that at the 5% level the barley-wheat bread was quite acceptable but at the 10% level the bread had a somewhat strong characteristic barley flavor which may affect its acceptance by consumers.

The results of the Avrami analysis on the aging of bread made from the various flours are shown in Figs. 2 and 3. The Avrami exponents for bread prepared from wheat flour, and 5 and 10% barley-wheat mixtures were 1.05, 0.99 and 1.06, respectively(Fig.2), indicating that the Avrami exponents for bread were

Fig. 1. Cut loaves produced from 100% wheat (left), 95% Wheat-5% Barley(center), and 90% Wheat 10% Barley(right).

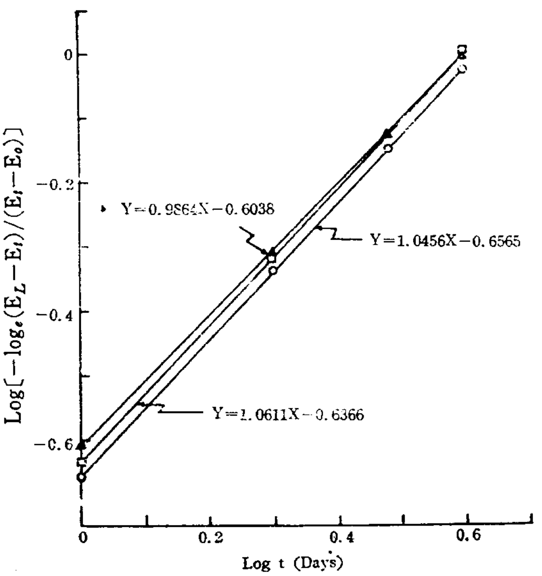

Fig. 2. Plot of $\log[-\log_e(E_L-E_t)/(E_L-E_o)]$ against log t of bread stored at 25°C.
○-○ 100% Wheat;
▲-▲ 95% Wheat-5% Barley;
□-□ 90% Wheat-10% Barley.

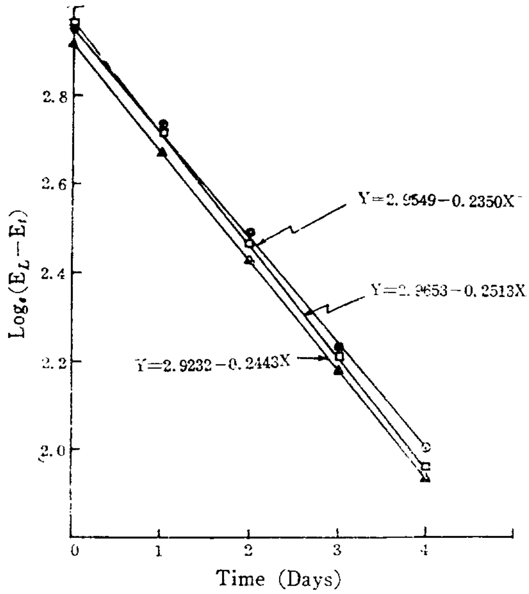

Fig. 3. Plot of $\log_e(E_L-E_t)$ against time of bread stored at 25°C.
○-○ 100% Wheat;
▲-▲ 95% Wheat-5% Barley;
□-□ 90% Wheat-10% Barley.

essentially unity in all cases. The same value(that is, n=1) has been reported for wheat-starch gels,[14] suggesting that the basic mechanism of bread staling involves changes analogous to crystallization of the starch fraction of the crumb, as reported previously.[15]

The values for the rate constant of bread made from wheat flour, and 5 and 10% barley-wheat mixtures corresponded to 0.2350, 0.2443 and 0.2513 reciprocal days(Fig. 3), giving time constants of 4.26, 4.09 and 3.98 days(Table 5). The results in Table 5 thus indicate that bread made from the composite flours did not influence the basic mechanism of bread staling but showed a somewhat lower value for the time constant, that is, faster rate of staling than the control. These results might be in accordance with the amylograph data which showed that the composite flours had higher paste viscosities than the wheat flour at all reference points, especially setback value (Table 1).

요 약

밀—쌀보리(품종 방사 6호)가루를 이용한 복합분(5,

및 10% 보리혼합)의 물리적 성질, 제빵적성 및 staling 속도를 조사하였다. 보리가루(60% 제분수율)는 밀가루보다 아밀로그라프의 점도가 높았다. 복합분도 밀가루보다 아밀로그라프의 점도가 높았으나 호화 온도에는 차이가 없었다. 복합분은 파리노그라프의 안정도가 밀가루보다 다소 낮았으나 엑스텐시그라프의 proportional numer는 큰 차이가 없었다. 복합분으로 만든 빵은 용적 및 내부특성이 밀가루빵보다 다소 열등하였고 staling속도는 다소 빨랐다. 이러한 현상은 보리 첨가량이 높을수록 현저하였다.

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