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A Study on Rheological Properties of Dough and Whole Wheat Bread-Baking Test of Wheat Variety *"Cho-Kwang"*

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韓国産 밀品種「조광」의 物理的 性質과 전밀빵 製造에 關한 研究

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Abstract

Rheological properties of the dough made from milled wheat products of various particle size, i.e., wheat shorts, girts and flour, and their effect on the loaf-volume potential of whole wheat bread were investigated in this study. One Korean wheat variety *"Cho-Kwang"* was tested for suitability in whole wheat bread. The percent ash and protein content of the milled wheat products were 2.3% and 13.7% respectively. Ranges of 7.3, 5.6 and 4.8 mixograph peak-height were observed in Fraction 1(wheat flours), Fraction 2 (wheat girts) and Fraction 3(wheat shorts), respectively. Dought stability of Fraction 1 did not decreased appreciably as compared to that of commercial first grade baker's flour. Bread-baking test employing a standard formula showed that the wheat grits (0.2—0.5 *mm* in diameter) appeared to be the limit beyond which a rapid decrease in loaf-volume potential was noted. Optimum loaf volume and crumb characteristics were obtained in 80% wheat grits/20% wheat flour blend.

Introduction

Although a large proportion of nutrients and calories of Korean is derived from rice, wheat bread consumption has also been increasing in recent years. The most popular bread offered in urban Korea is toast bread, which is made from hard wheat flours of ca. 75% extraction rate.

On the contrary, the annual production of wheat was steadily decreasing in last two decades, partly due to the unavailability of right kind of wheat variety for white wheat bread-making and partly due to the lack of knowledge of how to prepare other type of bread except for toast bread and other white breads.

Besides white wheat bread, there are many varieties of breads such as whole grain, high protein, and high fiber breads. In western countries, whole wheat breads have received considerable attention with regard to superior flavour, crumb characteristics and nutritients[1], and it has been attributed firstly to high micronutrients and secondary to their dietary values owing to high fiber content.

The micronutritients varies according to the stages of milling process. Rohrlich and Brücker[2] reported high levels of reduction of vitamine B group in refined wheat flours as compared to levels in wheat shorts and grits. Weaver *et al.*[3] observed that all micronutrients except for chromium were significantly reduced in the milling of barley into flour. Also, refining of wheat flour was shown to result in the removal of between 45% and 88.5% of seven essential trace elements[4]. In addition, Hinton[5] observed protein contents of the order of 6% in the inner endosperm compared to 14% in the outer endosperm, i.e., subaleurone cell. The fiber content was also reduced in the milling process.

Considerable information is available on the variation in wheat flour composition depending upon extraction rate. However, less information has been published on the rheological properties and whole wheat bread-baking potential of milled wheat products of different particle size. The aim of this study was, therefore, to evaluate rheological properties of the dough made from milled wheat products (variety: Cho-Kwang) of various particle size, i.e., shorts, grits and flour, and to test the suitability of the wheat variety *"Cho-Kwang"* for making whole wheat breads.

Materials and Methods

Wheat sample and analytical method

The wheat variety "Cho-Kwang" grown in Suwon in the 1982 season were selected to investigate dough rheology and baking properties of whole wheat bread. Moisture and ash contents were determined according to standard AOAC method[6]. Protein was determined by the micro-Kjeldahl procedure using copper sulfate-potassium sulfate as catalysts[7]. The moisture, ash and protein contents of all samples tested were calculated on a dry basis. Table 1 shows the moisture, ash and protein contents of straight milled wheat products.

Table 1. Moisture, ash and protein content* of milled wheat products

Moisture	13.8%
Ash	2.3% ± 0.8**
Protein	13.7% ± 0.6

* The ash and protein contents of milled wheat products were calculated on a dry basis.

** Mean value with standard deviations.

Milling

After conditioning to a moisture level of 14.0% for Cho-Kwang, the wheats were ground in a crushing mill and coarse wheat particles were sifted to separate the stock into three fractions, i.e., wheat flours (Fraction 1; less than 50 mesh size), grits (Fraction 2; between 20 mesh—50 mesh size) and shorts (Fraction 3; 7-20 mesh). Wheat shorts and grits were used as a base flour for a whole wheat bread-baking study.

Dough rheology

Wheat shorts, grits and flours were used to evaluate the rheological properties of dough. Mixogram measurements were made for mixing time, peak height, peak area, curve area, breakdown, width and height after 8 *min.*[8]. The Brabender farinograph equipped with 50 *g* bowl and the constant sample weight procedure of the AACC method[7,9], were employed to study mixing time, dough stability, elasticity and consistency of three fractions of milled wheat products.

Baking test

Two fractions of coarsely milled wheat products, wheat shorts and grits, were used for the preparations of whole wheat bread. Bread-making formular was; 80% wheat shorts or grits 20% wheat flour blend; salt, 2%; sugar, 6%; shortening, 4%; pressed yeast, 3%; non-fat dry milk, 3% and water. The general methods used in this study were based on those of Pelshenke[10]. To improve the texture of bread crumb and loaf volume, commercial first grade baker's flour was employed on a replacement basis at 20%.

Dough yield and bread yield were calculated in the following manner:

$$\text{Dough yield (\%)} = \frac{\text{Weight of Dough}}{\text{Weight of Milled Wheat Products}} \times 100$$

$$\text{Bread yield (\%)} = \frac{\text{Weight of Bread} \times \text{Dough Yield}}{\text{Weight of Dough}}$$

Loaf volume was determined by modified rapeseed displacement method after bread was cooled to room temperature[11]. Crust color, crumb grain, crumb texture and overall appearance of whole wheat bread were subjectively evaluated by laboratory personnels and photographed.

Results and Discussion

Rheological properties of the dough made from wheat shorts, grits and flours

A comparison of mixograph characteristics of hard wheat flour, wheat shorts and grits of various particle size was summarized in Fig. 1 and Table 2.

Relative dough strength was indicated by the peak height of mixogram. As shown in Table 2, the dough strength decreased as the particle size of milled wheat products increased. Ranges of 7.3, 5.6, and 4.8 mixograph peak-height were obtained within Fraction 1, Fraction 2 and Fraction 3 respectively. Similar results were given by the determination of peak area and height after 8 *min*. In all cases, dough stability had decreasing trends as the particle size of milled wheat products increased. As could be expected, commercial baker's flour had the strongest dough strength and stability in all samples tested.

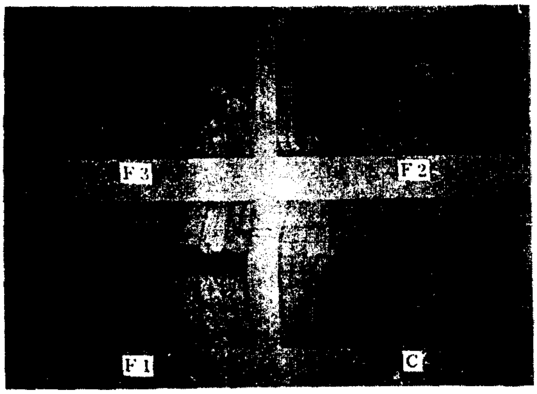

Fig. 1. The effect on mixogram patterns of milled wheat products (C; commercial first grade baker's flour, F1; less than 50 mesh, F2; between 50-20 mesh, F3; 20-7 mesh)

Water absorption decreased with increasing particle size of milled wheat products, and this phenomenon was more pronounced for samples between Fraction 2 and 3 than for samples between Fraction 1 and 2. The higher water absorption of Fraction 1 and 2 was due to increased starch damage by milling. The reduction in dough strength and stabilities and the variation in water absorption of various particle size determined in this study are in good agreement with those results obtained by Orth and Mander[12] and Faridi *et al*[13].

Farinogram of hard wheat flour, Fraction 1, Fraction 2 and Fraction 3 of milled wheat products were presented in Fig. 2 and Table 3. Farinogram data on water absorption, dough stability and other rheological properties were similar to mixogram data previously described. The unique deviation occurred in Fraction 3, which has lowest dough stability among all samples investigated.

Table 3. Farinograph data for wheat flour

Samples*	Water Absorption (%)	Mixing Time (*min*)	Dough Stability (*min*)	Elasticity (*BU*)	Consistency (*BU*)
Wheat flour	56	3	16	140	500
Fraction 1	65	10	10	80	500
Fraction 2	64	6	2	60	600
Fraction 3	58	22	—	80	600

* Refer to Table 2.

Table 2. Mixograph data for wheat flour

Samples*	Water Absorption (%)	Mixing Time (*min*)	Peak Height (*unit*)	Peak Area (*unit*)	Curve Area (*unit*)	Break-down (*unit*)	Width (*unit*)	Height After 8 *min* (*unit*)
Wheat flour	56.7±2.1**	2.8±0.3	7.3±0.6	20.3±1.5	40.3±2.1	1.0±0.0	1.7±0.3	6.3±0.6
Fraction 1	64.5±3.4	1.6±0.3	7.3±0.5	12.5±1.7	32.3±5.5	1.5±0.4	1.3±0.3	6.0±0.7
Fraction 2	65.8±1.7	2.1±0.8	5.6±0.3	10.3±0.3	27.2±2.6	1.8±0.3	1.0±0.0	3.9±0.5
Fraction 3	53.8±3.0	2.6±0.3	4.8±0.6	9.8±1.5	31.5±8.9	0.9±0.3	1.8±0.5	3.8±0.9

* Fraction 1: less than 50 mesh size
Fraction 2: between 50 mesh and 20 mesh size.
Fraction 3: between 20 mesh and 7 mesh size.
Wheat flour: less than 100 mesh size.

* Mean values with standard deviations.

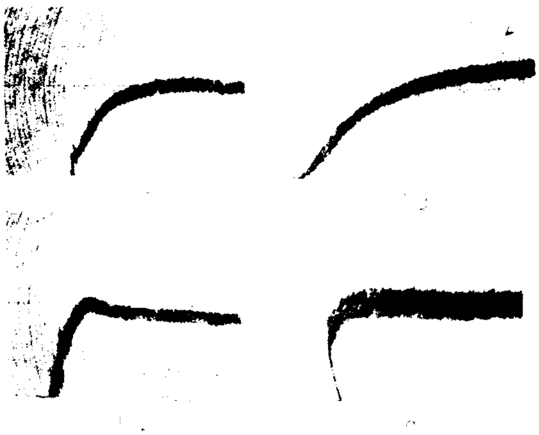

Fig. 2. The effect on farinogram patterns of milled wheat products.

Whole wheat bread-baking test

Two fractions of milled wheats, i.e., wheat shorts (7-20 mesh size) and wheat grits (between 20 mesh and 50 mesh size) were prepared for baking experiment. These results were given in Fig. 3 and Table 4. No change in water absorption occurred in wheat dough of sample A, B, C, D, E and F, but considerable variations of loaf volume were observed between samples. As the particle size of milled wheat products decreased, the specific loaf volume of whole wheat bread increased. When the 20% wheat grits were replaced with commercial first grade baker's flour, loaf volume and crumb texture were improved to some extent. Specific loaf volume of sample B reached 2.27 *ml/g* bread. More striking effects of wheat flour supplementation were observed in samples B and C. Specific loaf volume of sample C was 2.80 *ml/g* bread, whereas that of sample B was 2.27 *ml/g* bread. The difference in loaf volume between sample B and C could be ascribed to the different method of dough fermentation as suggested by Pelshenke[10]. The 80% wheat grits/20% wheat flour blend dough of sample C was pre-fermented at 28°*C* for 210 *min* before the straight dough procedure was followed.

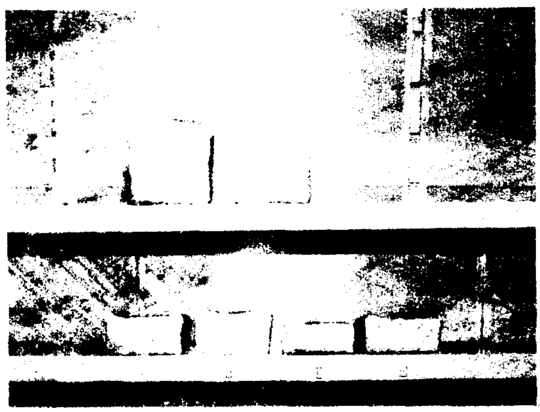

Fig. 3. Cut loaves prepared from wheat shorts, grits and wheat grits/flour blends
***Refer to Table 4.**

Table 4. Baking data for wheat flour-wheat grits blends

Samples*	Dough Yield (%)	Mixing Time(*1st*) (*min*)	Mixing Time(*2nd*) (*min*)	Proofing Time (*min*)	Loaf Volume (*ml*)	Loaf Weight (*g*)	Specific loaf Volume *ml/Kg* flour	Specific loaf Volume *ml/g*	Bread Yield (%)
A	181.0	3	7	50	1,238	617	3,295	2.0	169.2
B	181.0	3	7	51	1.425	628	3,793	2.27	167.2
C	181.0	3	7	40	2,555	914	4,624	2.80	165.4
D	181.0	3	14	45	892	605	2,374	1.47	161.0
E	181.0	3	10	40	1,095	604	2,915	1.81	160.8
F	181.0	3	10	40	1,925	908	3,484	2.12	164.3
Control	172.4	3	7	40	2,184	640	6336	3.94	158.8

* A: Wheat grits (Fraction 2), Dough was fermented for 80 *min* at 28°C.
B: 80% wheat grits (Fraction 2) + 20% wheat flour, Dough was fermented for 77 *min* at 28°C.
C: 80% wheat grits (Fraction 2) + 20% wheat flour, Dough was fermented for 210 *min* at 28°C.
D: Wheat shorts (Fraction 3), Dough was fermented for 76 *min* at 28°C.
E: 80% wheat shorts (Fraction 3) + 20% wheat flour, Dough was fermented for 90 *min* at 28°C.
F: 80% wheat shorts (Fraction 3) + 20% wheat flour, Dough was fermented for 180 *min* at 28°C.
Control. Commercial baker's flour

Increased crumb grain roughness was accompanied by the addition of wheat shorts. In particular, the specific loaf volume of samples D, E and F decreased to 1.47 *ml/g*, 1.81 *ml/g and 2.12 ml/g*, respectively, which represented about 23% decrease in loaf volume as compared with that of samples A, B and C. The major reason for the decrease seemed to be due to the dough instability of wheat shorts as shown in Fig. 1 and Fig. 2.

Desirable crumb and crust color were noted with wheat grits of less than 20 mesh size. In conclusion, the wheat grits of particle size between 20 mesh and 50 mesh appeared to be the limit beyond which a rapid decrease in loaf volume potential was observed.

요 약

本 硏究에서는 製粉된 밀을 입도別, 즉 wheat shorts, grits, 및 flour(粉) 等으로 分離하여, 그들의 物理的 性質을 調査하였으며, 더불어 입도의 크기가 전밀빵(whole wheat bread)의 부피에 미치는 影響을 檢討하였다. 試料로는 韓国産 밀品種인 「조광」을 使用하였다.

製粉된 밀의 조회분 및 조단백질의 含量은 각각 2.3% 및 13.7%이었다. wheat shorts, wheat grits 및 wheat flour의 믹소그라프 높이(mixograph peak-height)는 각각 4.8, 5.6 및 7.3이었으며 Fraction 1 (직경 : 0.2㎜이하)의 반죽의 안정도(dough stability)는 100*mesh*이하의 밀가루에 크게 뒤떨어지지 않았다.

제빵 實驗 結果로 보아 製粉된 밀 가운데 직경 0.2~0.5㎜ 크기의 wheat grits가 전밀빵을 製造하는 데 限界 입도된 듯 하며, 最適의 전밀빵의 부피 및 빵의 內部상태는 80% wheat grits/20% wheat flour의 試料区에서 얻었다.

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