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Quality Characeristics and Variation of Wheat Breeding Lines

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小麦育成系統의 品質特性과 変異에 関하여

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Abstract

Experiments were conducted to determine the physicochemical properties for 1,382 tested wheat harvested in 1977.

All the tested wheats had a milling yield rate of 49 to 71.5 percent. The cross combination involving S. son, Caprock and CI 12703 was generally the higher in flour yield.

Flour protein content ranged from about 7 percent up to about 17 percent and sedimentation values ranged from below 20 cc to 70 cc.

The cross combinations involving Bb #1 gave higher protein content and higher sedimentation values than the other combinations.

The distribution of the Pelshenke value was from less 20 min. to more than 180 min.

Specific sedimentation values of the 329 tested wheats showed 8.1 percent to be hard quality, while 54.4 percent were of soft quality. Intermediate wheats accounted for 37.5 percent.

The lines having high milling yield rate, protein content and sedimentation value from the 329 tested wheats were Strampelli x 69D-3607/Jogwang, S.son x Caprock, Suweon #185 x Toropi and Suweon #185 x Ciano. The varieties or lines including Pribog, CI 14496 and Sturdy x Scout/ Strampelli x Bb-Cno showed high milling yield but low protein content and low sedimentation values, being under 9 percent and 30 cc respectively.

Introduction

A wide divergence in wheat quality occurs, partly resulting from natural evolution and partly resulting from the planned breeding for high yield and resistance to diseases and insect that has been carried out duriring this century (Hehn and Barmore, 1965). But in recent years increasing emphasis has been placed on the quality of the grain for processing, specifically the milling quality and the baking quality.

Wheat quality is of necessity closely related on the milling rate. In an experimental milling operation, the yield of straight-grade flour is the most important factor though various other characteristics should be considered in judging over-all milling quality. The average yield of straight-grade flour is about 72 percent based on the cleaned wheat (Zeleny 1971). The question is frequently raised as to how well actual commercial milling quality can be predicted from experimental milling tests.

Mangels and Sanderson(1925) found that weight per unit volume is a rough index of the yield of flour that can be obtained. Baker and Golumbic (1970) showed that kernel weight was superior to test weight in predicting the milling yield for Hard Spring Wheat tested in a Buhler experimental flour mill.

Protein content in wheat varies from about 6 percent up to about 20 percent, depending in part on variety and class but more largely on environmental factofactors during growth (Kent and Evers, 1969 :Finney

et al., 1957) But an entirely different concept of wheat protiein quality is involved with the physical rather than the nutritional characteristics of bread and other end-products of wheat.

In many instances these differences are attributable to qualitative differences in the gluten proteins. Gluten quality is largely a varietal characteristic, although it has been shown by Finney and Fryer (1958)that high temperature and low relative humidities during the maturing period of wheat may have a marked deleterious effect on gluten quality.

There are two widely used tests to determine differences in gluten quality. The sedimentation test developed by Zeleny (1947) and modified by Pinckney et al. (1957) is a useful method for estimating the "strength" of wheat flour. The "Pelshenke test" (wheat-meal fermentation-time test, or dough-ball test), based on the work of Pelshenke (1933) and of Cultler and Worzella (1931), is widely used in many countries for estimating the potential bread-baking strength of wheat flour. The pelshenke test and the sedimentation value are both inflenced by the quantity and quality of the gluten.

Therefore, wheat-breeders have to select wheat varieties having equally satisfactory agronomic properties and superior processing quality.

Much research is in progress internationally to improve wheat production and quality but in Korea these studies on wheat quality of breeding material and advanced lines of is just starting.

These studies were carried out to determine the quality characteristics of the wheat tested by the Wheat and Barley Research Institute and to further improve wheat quality in connection with the wheat-breeding work through analysis of physicochemical properties.

MATERIALS AND METHODS

All wheats used in this investigation(crossing block: 120 varieties or cross combinations, advanced lines (F3 or greater) : 1,057, and yield trial lines : 205) were cultivated by the Wheat Breeding Division at the Wheat and Barley Research Institute.

Physicochemical properties of the tested wheat grain used the following method.

Wheats were tempered to 14 percent moisture for 24 hours using 150 gm sample before milling on a Brabender experimental mill. Flour yields were calculated from the scale weights of total recovered product.

The total nitrogen content was determined by the Kjeldahl method and converted into protein content using the factor 5.7 for wheat. Duplicate determinations were made on each sample, but in different runs to minimize errors. Duplicate values that did not fall within 2 percent of each other were repeated.

The sedimentation tests were determined by AACC Approved Methods (1969).

The pelshenke values were determined from 3 gm samples of whole-wheat meal made into a small dough ball with a yeast suspension. The dough ball was immersed in water maintained at a constant temperature. The time period between immersion of the dough ball and its disintegration was measured (AACC Approved Methods, 1969).

Dividing the sedimentation value by the percentage of protein the wheat gives a "specific sedimentation value".

RESULTS AND DISCUSSION

The primary objective of milling wheat is to increase recovery of the starchy endosperm and the protein. The potential amount of flour from wheat endosperm is about 82 to 84 percent of the grain weight. However, due to the complexity of the conventional milling process, the normal extraction rate obtained commercially from wheat is from 70 to 77 percent. The question is frequently raised as to how well actual commercial milling rates can be predicted from experimental milling tests. Accordingly, milling quality can be determined directly by means of experimented milling tests.

The yield of straight-grade flour is the most important factor in the physical criteria of wheat quality though various other characteristics should be be considered in juding over-all milling quality (Lawrance, 1971).

In this study, flour yields of 120 varietied or cross combinations from the WBRI crossing brock and 209 cross combination from yield trials ranged from 49.0

to 71.5 percent flour recovery a 60.3 percent in mean. (Fig. 1).

Korean native wheats gave milling yields of 57.2 to 62.6 percent.

The best flour yields were obtained from the 17 varieties (or lines) including Sturdy x Scout/Strampelli x Bb-Cno, S.son X Caprock and Young gwang X CI 12703. The cross combinations involving S.son, Caprock and CI 12703, had generally higher flour yields (Table 1.).

Table 1. High-milling rates among lines in the tested wheats

Variety (or line)	Milling rate (%)
Younggwang x Cl 12703	67.5
Bukgeun 3	66.8
Cl 14034	69.8
Expection	69.2
Fl-81-71	69.4
Pribog	69.6
Cl 14496	66.1
MV 6906	69.5
Sentivel	66.9
Martonvasar 3	66.8
Priboy	68.5
F 26-70	61.5
Strampelli x 69D-3607/Jogwang	67.0
Sturdy x Scout/Strampelli x Bb x Cno	68.1
S. son x Cl 12703/Toyae 3239	66.9
S. son x Caprock	65.1
Suweon # 185 x Toropi	65.0
Suweon # 185 x Ciano	66.8
Norin # 16 x 23584-Ciano	65.4
S. son x DI 12703	67.1

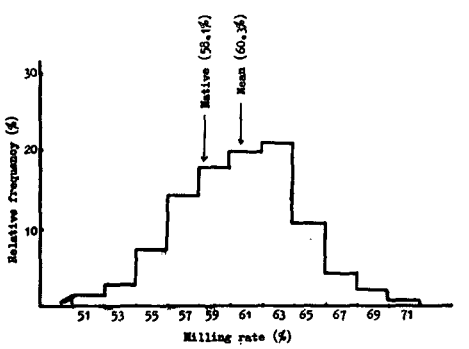

Fig. 1. Frequency distribution of milling rate of 325 wheat lines tested by the Brabender test mill.

Flour protein levels in the tested wheats are shown in Fig. 2. Flour protein levels in wheats from the tested wheats ranged from about 7 to 17 percent. Average for the 329 samples was 11.4 percent.

The group mean values of the Korean wheats were 9.5 percent in the crossing block and 9.2 percent in the yield trial lines. Korean wheats showed a lower protein than the overall avarage for the tested wheats, but the protein content of Suweon #210, a hard wheat bred in Korea markedly exceeded the average protein content for all tested wheats.

These results have shown that the protein content of wheat is quite variable and that the variation is lagely a varietal characteristic.

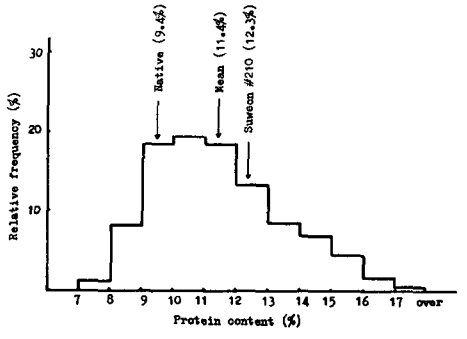

Fig. 2. Frequency distribution of protein content of 325 wheat lines tested by macro Kjeldahl method.

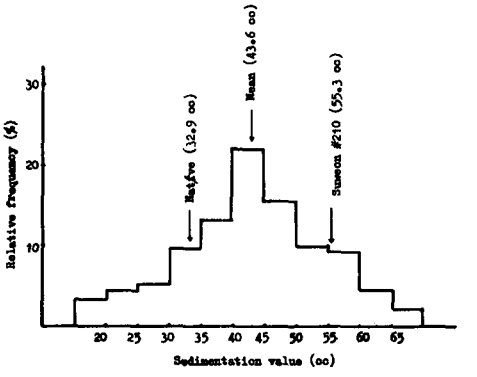

Fig. 3. Frequency distribution of sedimentation value of 325 wheat lines tested by AACC method.

Bice at al. (1945) pointed out that the proptein content of wheat is essentially a ratio between the amount of Protein and the amount of carbohydrate per kernal. In breeding new wheat culitivars it is undesirable to increase grain protein percentage by decreasing carbohydrate content since this lower yields. It is suggested that wheat- breeding work should first concentrate on higher grain and flour yield and later concentrate on higher protein content in Korean wheats.

Nutritional quality and physical quality involve entirely different concepts of quality of wheat protein. Both protein quantity and quality are considered to be primary factors in measuring the potential of a flour in relation to its end-use. The quantitative expression of crude protein is related to total organic nitroggen in the flour, whereas quality evalutions relate specifically to physicochemimical characteristics of the gluten-forming component (Pratt, Jr., 1971). Gluten content can be used as a criterion in the classification of wheat protein.

The sedimentation value is influenced both by the quantity and the quality of the gluten. This test estimates the "strength" of wheat flour.

This study revealed that the sedimentation values of the tested wheats ranged from below 20cc to 70cc with 43.6cc as the mean (Fig. 3). While the group mean values of the Korean wheats were 32.9cc, Suweon #210 showed a relatively high sedimentation value.

The sedimentation test requires much less time than pelshenke test and because of its greater objectivity, better agreement among replicate tests can usually be obtained. Zeleny et a . (1960) have pointed out the usefulness of the sedimentation test in early-generation wheat breeding work.

Comparisons of the protein content with the sedimentation value reveal that a significant positive relationship exists (Table 2 and 3). The results agree closely with the report of Ryu et al. (1977).

The protein content and sedimentation values of the 329 tested wheats, showed 6 cross combinations, including Bb #1 x Sturdy and Junggug #81 x Atlas 66, were the highest giving values of over 15.0 percent protein content and over 60.0 cc sedimentation values (Table 2). Lower protein content and sedimenation values were found in the Korean and introduced wheats Pribog, CI 14496, Weonggwang, Junggug #81 x Suge (Table 3.).

It was observed that the cross combination which involved Bb #1, had higher protein content and sedimentation values than other combinations.

Though the protein content and sedimentation value vary according to environment, varietal difference was the more significant factor affecting these two traits.

Table 2. High-Protein content and high sedimentaton values among lines in the tested wheats.

Variety (or ilne)	Protein content (%)	Sedimentation Value (cc)
Redstar x Cno- Bb	15.28	68.3
Shiroganegomugi	14.25	51.3
S. son x Suweon #155	13.05	60.8
Bb # 2 x Yukseong # 3 (Redstar x sturdy / Redst- Redstar x Cno- Bb)	16.59	62.0
Bb # 1 x Sturdy	17.27	66.8
Calidad x Janggwang	15.79	53.5
Stramfelli x 69D-3607/Jogwang	13.40	50.8
Sturdy x Seoyuk #93/Redstar x 13	14.76	65.8
Sturdy x Inia	15.16	62.3
Bb # 1 x Suweon #169/Redstar x 69D-3607	13.40	58.3
Suweon #185 x Ciano	13.57	59.5
Sturdy x Bb # 3	15.96	62.5
Junggug #81 x Atlas 66	16.86	65.3
F_3 (Younggwang x Akazuki)/Cno-Chris-On	15.05	66.2
Cno"s" x Siete-Cerros/Triumph	15.11	61.0
S. son x Caprock	14.59	60.5
Suweon #185 x Toropi	15.45	59.7
(Younggwang x Norin # 4 /Bb # 3) 23854—Inia	13.65	60.6
Sturdy x Bb # 2	14.59	65.8
F_3 (Younggwang x Norin #72) Bb # 1	16.23	56.3

Table 3. Low protein contentand low sedimentation values among level in the tested wheats.

Variety or cross combination	Protein content (%)	Sedimentation value (cc)
Junggug #81 x Suge	7.78	20.2
Suweon #185 x Littotio	8.58	22.3
Sutrdy x Scout/Strampelli x Bb—Cno	8.21	29.3
Suweon #185 x S. son/Caprock	8.19	21.3
Jogwang x CI 12703	8.43	26.6
Yukseong # 3	8.84	N[1)]
Weongwang	7.07	N
Namgwang	8.66	N
Pribog	7.18	27.8
CI 14496	8.00	21.0
R 37 Gallis 121	8.04	25.0
Capitole	8.44	28.0
Blue boy	8.35	N

1) N : Results uncertain

Table 4. High and low Pelshenke value among lines in the tested wheats.

Classification	Variety (or line)	Pelshenke value(cc)
High	F_4 (S. son x Caprock)/Tob—Cno"s"	167.7
	NB 66425 x Ciano 67	151.8
	Weongwang x 23574—Inia	142.8
	Bezostaya x Bb # 2	157.0
	NB 68513 x Bb # 2	180.1
	Cno "s" x Siete—Corros/Triumph	149.0
	Janggwang x Sturdy	168.5
	Roussalka x Bezostaya	160.5
	Bb # 2 x Yukseong # 3 (Redstar x Sturdy/Redstar x Cno—Bb)	179.0
	Calidad x Janggwang	154.0
	Bb—Cno x CT 12703	167.5
	S. son x Caprock	162.5
Low	Junggug #81 x Roussalka	43.4
	Jogwang x TT/T :T	37.0
	Bb # 3 x Weongwang/Jogwang x Junggug #81	41.0
	Bb # 4 x Suweon #169/Rosusalka	331.0
	Tepp—son 64—Nar (LR 64—Son 64 x Nar 063) Jogwang	41.0
	CT 14034	17.0
	Atlas 66	28.5
	(Younggwang x Norin # 4 /Bb # 3) 23584—Inia	28.0
	Norin #16 x Tob—Cno	S 1)
	On x Tob—Noname	S
	Bb #1 x Suweon 169/Redstar x 69D—3607	24.5

S : Very weak

The Pelshenke test (test wheat-meal fermentation-time test) is widely used in many countries for estimating the potential bread-baking strength of wheat. This time will vary from less than 30 min for very weak wheats to more than 400 min. for the strongest wheat (AACC Approved methods, 1969). The test number is influenced both by the quantity and the quality of the gluten.

The changes in Pelshinke value are given in Fig. 4. These results pointed out that the distribution of the Pelshenke value ranged from less than 20 minutes for very weak wheats to more than 180 minutes for the strong wheats.

The mean of Pelshenke value for the 120 wheats from the crossing block and the 1,057 lines from F3 or more advanced generation was 89.9 minutes.

The group mean values of the Korean native were 31.7 percent, Korean native showed a too low Pelshinke value.

Table 4 indicate that the highest Pelshenke values were 180.1 minutes (NB 68513 x Bb#2) and 179.0 minutes. (Bb#2 x Yukseong #3(Redstar x Sturdy/

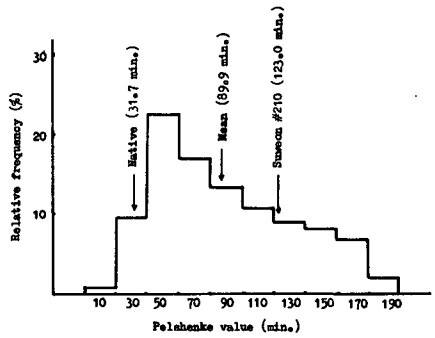

Fig. 4. Frequency distribution of fermentation property of 1177 wheat lines tested by AACC method.

The classification of wheat as hard or soft depends on protein content, sedimentation value or Pelshenke value. The use of one of these is liable to confuse the criterion of classification.

In order to classify wheat as soft or hard, dividing the sedimentation value by the percentage of protein in the wheat gives a "specific sedimentation value "that can be used as an index of wheat quality.

The specific sedimentation values included in Table 5 ascribed hard wheats in the crossing block and yield trial lines 4.9 and 11.2 percent respectively, while those of soft wheat were 60.2 percent and 48.1 percent. Intermediate wheat marked each 35.0 and 40.0 percent (Table 5.).

Lawrence (1971) has reported that bread-baking strenght can be estimated more accurately from the sedimentation value than from specific sedimentation value, since sedimentation value is influenced by both quantity and quality of the gluten.

Table 5. Distribution of specific sedimentation values for tested wheats[1]

Source	Specific sedimentation value		
	below 4	4 to 5	above 5
Corssing block	60.1%	35.0%	4.9%
Yield trial	48.8	40.0	11.2
Mean	54.4	37.5	8.1

1) Specific sedimentation = $\frac{\text{sedimentation value}}{\text{Percent protein}}$

Redstar X Cno-Bb). Varieties and lines, such as CI 14034, Norin #16 x Top-Cno and On x Tob-Noname, gave relatively low Pelshinke values of less than 20 minutes.

The wheat in most parts of the world is milled to a more refined product. Most of the physical criteria of wheat quality such as the weight of the wheat per unit volume, kernel weight, kernel hardness etc. are based on relatively simple examinations and are of value inasmuch as they to some degree predict the milling quality of the wheat or the baking quality of flour milled from the wheat.

Research trys to produce wheat varieties with higher grain yield and with an increased percentage of flour yield. Because wheat quality is programs judged by its suitabality for a particular end-use, wheat-breeding programs try to develop new varieties having good protein contents desirable sedimentation values and Pelshenke values etc. leading to the production of desirable noodles and cookies.

Hard wheat production in Korea is expected to increase with the newly developed variety Suweon #210, because of its desirable protein content and sedimentation value. Other desirable lines identified by this study include, Strampelli x 69 D-3607/Joggwang, S.son x Caprock, Suweon #185 x Ciano. These lines had higher flour yields, protein contcent and sedimentation values. The higher flour yielding wheats with low protein content and sedimentation values were Pribog, CI 14496 and Sturdy x Scout/Stramplli x Bb-Cno. There are additional high-yielding varieties and lines with good quality proterties which will be selected as promising lines.

SUMMERY

These studies were conducted to determine the quality characteristics of the wheat tested by the Wheat and Barley Research Institute and to further improve wheat quality in connection with the wheat-breeding work through analysis of physicochemical properties.

The results obtained are summerized dollows :

All the tested wheats had a milling yield rate (by Brabender experimental mill) of 49 to 72 percent with a 60.3 percent in mean and Korean native wheats gave milling yields of 57.2 to 62.6 percent. The cross combination involving S.son, Caprock and CI 12703 was generally the higher in flour yield.

Flour protein content ranged from about 7 percent up to about 17 percent and averaged 11.4 percent. Korean native wheats showed a lower protein content with 9.35 percent as the mean, but Suweon #210, a hard wheat bred in Korea, markedly exceeded the average protein content for all tested wheats.

Sedimentation values ranged from blelow 20 cc to 70 cc with 43.6 cc as the mean. The group mean values of the Korean native wheats were relatively lower than the average of all tested wheats but Suweon #210 showed a high sedimentation value.

6 cross combinations, including Bb #1 x Sturdy and Junggug #81 x Atlas 66, were the highest giving values of over 15.0 percent protein content and over 60.0 cc sedimentation value. The cross combinations involving Bb #1 gave higher protein content and higher sedimentation values than the other combinations.

The distribution of the pelshenke value was from less than 20 min. to more than 180 min. with 89.9 min. as the mean. Average for the Korean native was 31.7 minutes.

Specific sedimentation values of the 329 tested wheats showed 8.1 percent to be hard quality, while 54.4 pereent were of soft quality. Intermediate wheats accounted for 37.5 percent.

The lines having high milling yield rate, protein content and sedimentation value from the 329 tested wheats were Strampelli x 69D-3607/Jogwang, S.son x Caprook, Suweon #185 x Toropi and Suweon #185 x Ciano. The varieties or lines including Pribog, CI 14496 and Sturdy x Scout/Strampelli x Bb-Cno showed high milling yield but low protein content and low sedimentation values, being under 9 percent and 30 cc respectively.

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적 요

소맥의 품질특성규명 및 품질개선을 위한 기초자료를 얻고자 일연의 시험을 수행한바 그 결과를 요약하면 다음과 같다.

제분율은 품종에 따라 49~72%으로서 평균60.3%였으며 한국 재래종의 전체 평균은 62.6%를 보였다. 일반적으로 S. son, Caprock 그리고 CI 12703이 교배된 조합이 제분율이 높았다.

단백질 함량의 평균은 11.4%으로 품종에 따라 큰 차이가 있어 7—17%의 범위에 있고 한국 재래종의 평균 9.34%로 낮은 경향을 보였으나 수원210호는 전체 평균보다 월등히 높았다.

침전가는 20cc 이하에서 70cc의 범위로 평균 43.6cc 였으며 한국 재래종은 낮았으나 수원210호는 높은 침전가를 보였다.

Bb# 1 x Sturdy, 중국81 x Atlas66 등 6개의 교배조합은 15.0% 이상의 단백질함량과 60.0cc 이상의 침전가를 보였으며 일반적으로 Bb# 1 이 교배된 조합이 단백질함량과 침전가가 다른 조합보다 높았다.

Pelshenke value의 분포는 20분 이하에서 180분 이상으로 평균 89.9분 이었고 한국 재래종의 평균은 31.7분으로 극히 낮았다.

비침전가에 의하면 8.1%가 경질소맥인 반면 54.4%가 연질소맥, 37.5%가 중간질로 분류 되었다.

329개 공시계통(또는 품종)중 제분율, 단백질함량 및 침전가가 높은 교배조합은 Strampelli x 69D—3607/Jogwang, S. son x Caprock, Suweon #185 x Toropi 그리고 Suweon #185 x Ciano 였으며 Pribog, CT 14496 및 Sturdy x Rcout/Strampelli x Bb—Cno는 제분율은 높으나 단백질 함량과 침전가가 각각 9%, 30cc 이하로 낮았다.