原 著

Study on the Milling Yield of Pearled Wheat Using an Experiment Mill

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<Abstract>

Optimum milling condition for hard wheat (1CW) according to the unique milling system, patented Tkac procedure was studied using the Buhler's experiment mill. The Tkac system involves preprocessing the wheat by removing the outer kernel layers during sequential friction and abrasion passages through a pearler. The pearled wheat is then milled by conventional roller mills. The experiment focused on the better milling yield when using the unique milling system. As a result, it was found that tempering was as useful for the milling system as the conventional milling procedure and that the optimum pearled ratio was around 90% to obtain the maximum milling yield. The experimental milling using 90% pearled wheat on the actual production line indicated that an appropriate milling diagram has to be designed for this unique milling system, since a large yield of semolina from 1B roll reduced both the milling flow rate and flour quality significantly.

Key words: wheat, milling, pearling

It is an eternal task for the milling industry to increase the milling yield. Even the 0.1% increase in the milling yield produce visible profit to the industry who is milling tons of wheat per an hour. In order to raise the milling yield, various improvements have been continuously tried on milling equipments such as a sifter, a purifier, an air-classifier, and also on a milling diagram. These efforts are paid for targeting the complete separation of the endosperm starch from other wheat components.

As one of the trials for the purpose mentioned above, numerous investigation has been done to pursue the possibility, that is, the removal of wheat pericarp before milling might improve the milling yield (Grosh *et al*, 1960; Pomerantz, 1961; Wasserman *et al*, 1970, 1972; Liu *et al*, 1986; Henry *et al* 1987). Although these former efforts couldn't achieve the satisfied milling yield or refinement of wheat flour causing inferior quality in the final baking products, 1990's works (Satake, 1990; Sugden, 1991; McGee, 1992; Timm, 1992; Willm, 1992) could get a clue to diffuse the milling system to the industry as shown in the two significant U.S. Patent (Tkac, 1992; Wellman, 1992). Dexter (1994) demonstrated in the durum wheat milling that the Tkac system increased plant capacity, increased milling yield, improved flour refinement resulting in the superior spaghetti quality, and simplification of the mill flow. His work leads the practical application of the Tkac system into the durum milling industry in world wide.

In the Tkac system, wheat is preprocessed by removing bran layers during sequential friction and abrasion passages through modified rice polishers, and then milled by conventional roller milling equipment (Tkac, 1992). In this study,

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we investigated the effect of moisture addition on tempering stage and the optimum level of pearling ratio to get a maximum milling yield as a preliminary experiment using a Buhler's experiment mill. The results were considered to evaluate whether the Tkac system is practically applicable to Japanese milling system.

MATERIALS AND METHODS

Wheat

The Canadian wheat 1CW (the No.1 Canada Western Wheat) was drawn from a commercial channel. The nutritional compositions are as follows: ash, 1.52%; protein, 13.5%; moisture, 13.2%.

Wheat pearling

The bran layers are removed during sequential friction and abrasion operations by a series of passing through the Satake test mill (a type of hammer mill) model TM05C without using any sieve. About 0.1% of pearling was achieved with one passing through the machine. The debranning treatment was repeated until the desired degree of pearled ratio for every wheat kernel samples were obtained.

Ash content

Ash content was determined by AACC methods 08-01 (AACC, 1983)

NMG staining

NMG staining of the pearled wheat kernel was conducted according to the modified method (NARC1999nrc99S009) of Standard Analytical Method of Japan General Food Policy Bureau (p94-97, 1989) as follows. Pearled wheat kernels were soaked in tapped water for about 10 seconds, then after the water was drained off, kernels were soaked in New MG solution of the original concentration (Wako, special grade prepared for the use of starch staining) for 2 min. Stained kernels were washed with methanol for three times and dried at room temperature on an appropriate paper. As a result, starch is stained to pinkish color and aleurone is stained to dark greenish color.

Milling

Samples (that are control and pearled samples) were tempered to desired percentage wb and conditioned for 24hr at 20℃. Samples of 2kg were milled in an experiment mill (model MLU-202, Buhler Inc., Uzwil, Switzerland) at a feed rate of 100g/min. Flour yield was calculated on a total product basis and adjusted for the loss of bran that resulted from pearling action.

RESULTS

Relation between pearled ratio and kernel ash content

Flour ash content is the representative indicator of flour refinement. An increase in flour ash content is indicative of less refined flour because the starchy endosperm has a much lower ash content than does aleurone or pericarp tissue (Symon and Dexter, 1993). Since various enzyme activities such as proteases, amylases, oxidases and lipases are localizing in the aleurone, the flour contaminated with aleurone exhibits worse baking performance and inferior quality in the final products. Pericarp enhances the oxidative deterioration of flour and it gives nasty smell and taste to the baking products. Therefore, wheat flour derived from essentially pure endsperm is highly valued because of its brightness and superior processing capability (Ziegler and Greer, 1971).

Figure 1 shows the effect of wheat pearling treatment on decrease in kernel ash content. As expected, pearling treatment decreased the kernel ash content as the pearled ratio decreased, and the lowest ash content was 0.61% at 40% pearled ratio. Beyond the pearled ratio of 40%, the kernel ash content unexpectedly started to increase. In order to know the reason, NMG staining was performed to the pearled wheat samples as shown in Figure 2. This result shows that the wheat pericarp and aleurone are almost completely removed at the pearled ratio of 70%, but the crease can't be removed by the pearling treatment even at 20% pearled ratio. The reason why the kernel ash content started to increase beyond the 40% pearled ratio is that crease area increases relatively to the endosperm beyond the 40% pearled ratio. This result indicates that the crease must be removed efficiently by some technical efforts in this milling system. In the conventional milling system, crease is well removed together with bran portion. But in this unique milling system, since the bran is scraped off from the crease, some particular technique must be required to eliminate the crease from the flour for achieving the excellent flour refinement.

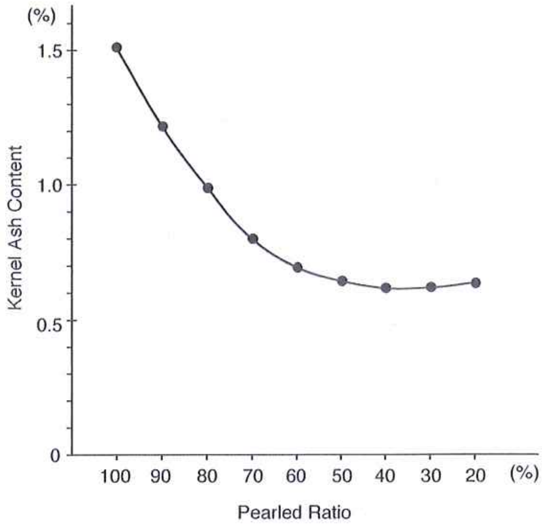

Figure 1. Relation between pearled ratio and kernel ash content.

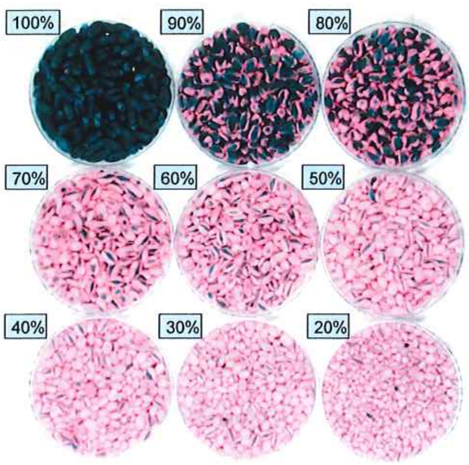

Figure 2. Result of NMG staining of the pearled wheat kernels. The % indicated on the left upper corner of each photograph means the pearled ratio of the kernel.

Effect of tempering moisture content on milling performance

Tempering procedure is essential for the conventional milling procedure in order to remove the bran effectively according to strengthening the bran making it like a parcel wrapping over the starchy endosperm. The parcel like bran can be stripped and slipped off easily from the endosperm at the break roll of 1B by the twin-roll combinative action of the dull-dull corrugation and the different rotation speed. But for the pearled wheat kernel, those contribution of tempering treatment is hard to be expected. So at first, the effect of the tempering the pearled wheat samples in this unique milling system was compared with the conventional milling procedure.

Unprocessed wheat, and pearled wheat both at 90% and 80% pearled ratio were tested under tempered and non-tempered conditions. For the tempered wheat, the samples were tempered to 16.0% moisture content. The results were shown on Figure 3. Better milling yield was obtained when the wheat is tempered both at unprocessed and pearled wheat. Better 1M stream yield was also obtained under wheat's tempered condition at all samples tested. When considering the optimum pearling ratio for the maximum yield, 90% pearled wheat exhibited the best yield in the total milling yield and also in the 1M stream.

Optimum pearled ratio for obtaining maximum milling yield

The optimum pearled ratio was examined between the range of 100% and 80% pearled ratio under the condition of that all the samples were tempered to 16.0% moisture content. The result was shown in Figure 4. According to the result, it was shown that the best pearled ratio of the wheat to get the best milling yield exists around 90% ratio. All the milling yields obtained from the pearled wheat were better than control (conventional milling, shown as 100% pearled ratio on Figure 4). On the other hand, the 1M stream yield showed inferior to the control beyond the 85% pearled ratio.

Application to an actual milling

The pearled wheat was experimentally milled at an actual commercial plant. 10 tons of 1CW wheat which was conditioned to 17% moisture level, was pearled to 90% ratio with the Satake Pearler model FMTD5A. The reason why the pearled ratio of 90% was chosen was due to the result of that the experiments using experiment mill mentioned above showed the 90% pearled ratio is appropriate to obtain the maximum milling yield. The pearled wheat was milled at a commercial milling line for hard wheat. The brief result of the practical experiment (data not shown) was as follows. Semolina production rate at 1B roll was increased more than twice, as the result of that several pneumatic pipe lines were choked up and overflowed finally. In order to continue the wheat milling in the plant, there was no choice other than reducing the milling flow rate of the plant to 5.5t/hr from 9.0t/hr. Actually in the practical plant management, it is not allowed to reduce the milling capacity, since it means the economical profits goes down. In this practical experiment, the ash contents of obtained streams increased compared with the conventional milling streams. Especially the streams that usually exhibit good baking performance and also that compose 1st grade flour, that is, 1-2B, 1-2M, 1-2S showed significant increase in their ash contents.

DISCUSSION

Grosch *et al* (1960) reported the outer pericarp could be efficiently removed by the abrasive scouring (pearling) of wheat. They didn't mention about the crease contamination in the flour, but our result showed that when the pericarp was removed to 70% pearled ratio, the crease can't be removed by scouring from the wheat flour. So far, the pearled wheat milling

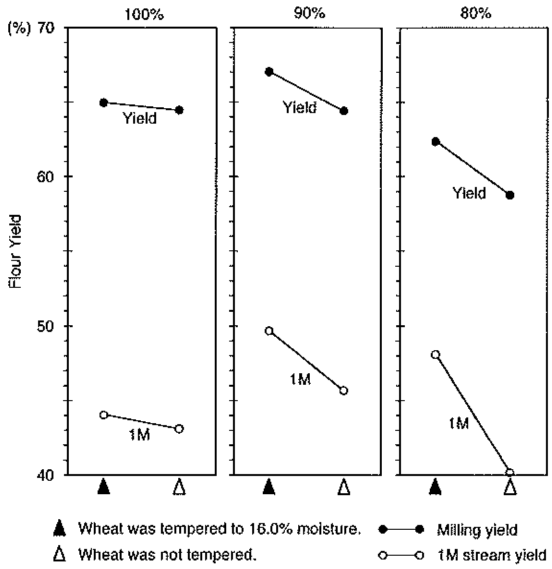

Figure 3. Milling yield and 1M stream yield when wheat of various pearled ratio were milled with and without tempering conditions. Pearled ratio (%) is indicated on the top of each graph. For the tempered wheat, the samples were tempered to 16.0% moisture content. Milling yield is the total ratio of all the streams, that is, 1B, 2B, 3B, 1M, 2M, 3M. All the data were averaged from repeated experimental results for five times.

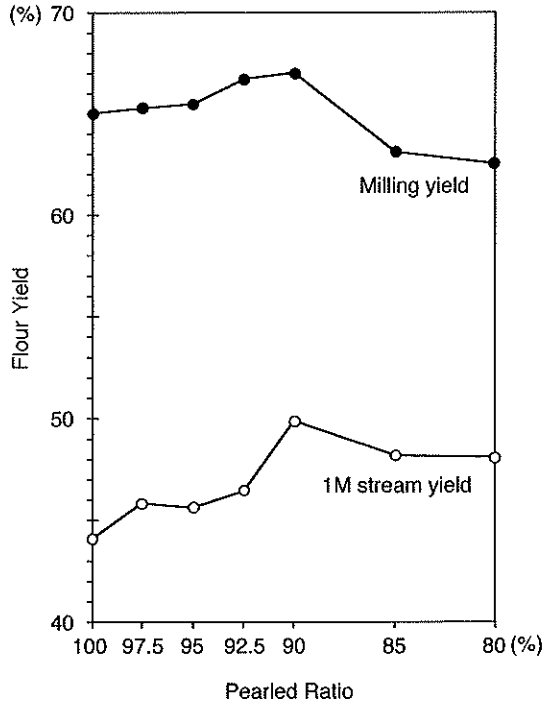

Figure 4. Milling yield and 1M stream yield when wheat of various pearled ratio were milled. All the samples were tempered to 16.0% moisture content. All the data were averaged from repeated experimental results for five times.

system is practically utilized particularly for durum semolina production. Probably the unique milling system must be suitable for collecting the large particle endosperm from very hard wheat like durum wheat that has crystalline endosperm. The reason is hard to presume now. Also the reason why the semolina yield at 1B roll on the milling test performed in a commercial production line is remarkably different from the result of the experiment mill is unknown. There was no significant increase observed in the yield of break rolls at the experiment mill tests in this study. In the commercial production of the durum semolina, most of the products are gained at the 1B roll (Dexter *et al*, 1994). This explains why the unique system is applicable to the durum semolina production.

Tempering treatment on the pearled wheat was effective for obtaining the better milling yield in this study. As shown in Figure 2, wheat bran is remained in the surface of the kernel at the 90% pearled ratio. Thus the tempering treatment is considered to be able to work for strengthen the bran parcel as same as conventional milling procedure. This fact indicates the reason why the 90% pearled ratio is ideal for producing the maximum milling yield. As mentioned previously, tempering treatment is essential for the conventional milling procedure in order to remove the bran effectively according to strengthening the bran, making it like a parcel wrapping over the starchy endosperm, and then the bran can be stripped off easily from the endosperm at the break roll of 1B both by the twin-roll combinative action of the dull-dull corrugation and the different rotation speed. Beyond the 80% pearled ratio, only the small portion of bran is remained on the surface of the wheat kernel, thus the bran can't be removed as usual way as the conventional milling.

The experimental milling using 90% pearled wheat on the actual production line indicated that an appropriate milling diagram specific for this unique milling system has to be designed, since a large yield of semolina from 1B roll reduced the milling flow rate significantly and flour quality. In order to apply this unique milling system to the commercial wheat flour milling other than the spaghetti's semolina milling, further study using a commercial plant has to be done with the consideration of the specific milling diagram in relation to the quality of the baking product as well as milling yields.

ACKNOELEDGEMENTS

We are grateful to people in the Wheat Breeding Lab., Kyushu Agricultural Experiment Station (the present organization is National Agricultural Research Center for Kyushu Okinawa Region, Chikugo, Fukuoka Pref. Japan) for their co-operation during the experiment milling and excellent technical assistance.

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テストミルを用いた搗精小麦の製粉歩留りに関する研究

甲斐　達男　　安部　翔子

＜要　旨＞

新しい製粉システムであるTkac特許製法によるハード系小麦（1CW）の最適製粉条件の検討を、ビューラー社のテストミルを用いて実施した。Tkacシステムでは、小麦を搗精機に通すことによって連続的に摩擦をかけ、小麦粒の表層部を擦り減らすという前処理を行なう。その後、搗精した小麦を一般のロール製粉にかける。今回の実験はこの新しい製粉システムによって製粉歩留りを上げることに焦点をおいた。その結果、一般の製粉方式と同様に、テンパリングが有効であることが分かった。また、最高の製粉歩留りを上げる最適搗精度は90%程度であることが分かった。実際の製粉ラインで90%搗精麦を用いて試験製粉を行なったところ、1Bロールからセモリナが大量に発生し製粉流速をかなり落とさなければならなくなったことと、小麦粉の品質が劣化したことから、この新しい製粉方式に適したダイアグラムを組まなければならないことが示された。

キーワード：小麦、製粉、搗精