水稻乾燥與碾米率及稻米品質之關係

Rice Drying in Relation to Milling Yield and Quality of Rice

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摘　　要

馬拉威共和國碾米業所遭遇之最大困難就是水稻乾燥問題。根據過去碾米經驗，水稻在碾米時往往產生全粒米率太低而碎米率偏高之現象，其主要原因爲水稻收穫後未經適當之乾燥處理，因而含水量高，以及碾米前稻谷中胴裂率大，均直接影響碾米率及碎米率。

由過去四年之碾米數據分析結果顯示，馬拉威之碾米率平均約爲 64 %，但乾燥試驗證明水稻如經過適當之機械乾燥或日晒乾燥處理，則碾米率可達 70 %以上，對於農民收益及稻米經濟價值影響甚大，故水稻乾燥爲亟待解決之問題。在機械乾燥因稻米產量不大而成本較高之條件下，日晒乾燥爲最節省能源之乾燥方法，應在小戶稻農及灌溉稻區普遍推廣。同時政府收購水稻之方式亦應改善，水稻價格應以含水量，胴裂率，純潔度以及成熟度等因素爲分級標準訂定之，以鼓勵農民生產高品質之水稻。

1. Introduction

There is no written record to suggest how long rice has been grown in Malawi, but it is most likely that rice was originally brought into the country by the Arabs during slave trade and by Indian migrants at the beginning of the century. Until 1940s when commercial rice milling using modern milling machinery was introduced in Malawi, rice was grown on subsistence level employing traditional methods of growing, harvesting, drying and shelling using mortar and pestle. During the past fifteen years or so, rice production has become largely commercialized employing some latest improved methods of growing, milling and parboiling. However, despite this remarkable improvement in growing methods and milling techniques, rice drying remains a single major area that needs urgent attention in order to improve milling yield and overall quality of milled rice.

Several factors are generally recognized as contributing to breakage of rice during milling. Cracking of the kernel is known to be one factor since delayed harvesting causes the crop to undergo cycles of drying in the day-time and wetting from dew in the night or from rain and thus develops cracks which subsequently break during the milling process giving rise to increased amount of broken kernels. High moisture

content in addition to immaturity and chalkiness, shape and hardness of kernels also contributes to breakage of rice during milling. Being hygroscopic, visco-elastic material, the mechanical strength of the rice grain is influenced by its content of moisture. The lower the moisture content, the stronger is the kernel and vice-versa. In its practical implication, the kernel is considerably weakened above 14% moisture, when it is no longer able to sustain excessive stresses during milling. Uneven distribution of moisture within the kernel also lowers its mechanical strength considerably and makes it susceptible to easy fracture.

Although there is general awareness about these factors, quantitative data is not readily available and little documented evidence exists.

It is partly because of this apparent lack of data and partly because of persistent low milling yields experienced over many years that lead the National Oil Industries Limited (NOIL) to conduct an experiment at its Blantyre Rice Mill to determine the effects of drying paddy under different conditions on milling yield and quality of milled rice in contrast to traditional methods of drying paddy.

2. How Paddy is Dried in Malawi

2.1 Small Scale Growers

In Malawi sun-drying is the only method of drying paddy and because first crop paddy is usually harvested in April/May before rains are completely over the weather conditions are not conductive to uniform drying of paddy. Ideally, paddy should be harvested when the moisture content is about 20-22% and carefully sun-dried. Very often crop management is a problem experienced by small scale farmers in Malawi who grow the bulk of paddy. As paddy matures and ripens when other crops are ready for harvesting it is common for a small farmer to split his labour between paddy and other crops or to harvest paddy rather late. Late harvesting of paddy results in overripeness and excessive exposure to the sun in the daytime and wetting from dew and rain at night. These conditions set up stresses in the kernel which then cracks across its length. It is these weakened grains that easily break upon milling.

2.2 Irrigated Schemes

On the other hand while paddy grown on irrigated schemes may be harvested immediately after attaining maturity, it is not thoroughly sun-dried, and in some cases, it is bagged at as high as 20% moisture content. Paddy growers at various irrigated schemes in the country get such inputs as seed, fertilizer and pesticides on credit terms. In order to recover expenses in respect of these inputs, farmers are anxious to sell their paddy to the Agricultural Development and Marketing Corporation (ADMARC) as soon as possible, and ADMARC, in turn, buy the paddy rather wet for fear that any delay would encourage black market. The paddy is then delivered to NOIL rice mills for milling

before it is thoroughly dried to 13-14% moisture content. Large quantities of such wet paddy are stacked in sheds occupying limited storage space, and much of the drying takes place during the first month of storage in the sheds which are poorly ventilated because paddy sheds have not been designed to dry wet paddy. This poorly dried paddy results in a high yield of broken rice when it is milled.

3. Effects of Poor Drying on Milling Yield and Quality of Rice

3.1 Low Milling Yield

Paddy drying is very delicate process of great economic importance to rice processing industry as its profitability is largely measured by its ability to increase recovery of head rice and reduce as much as possible the amount of broken rice. In fact, paddy grown by small scale farmers is harvested rather late and dried too rapidly in direct sun light resulting in development of cracked kernels which break excessively upon milling, thus reducing milling yield. Table 1 compares milling yields achieved at various NOIL mills over a four year period. It is evident from the tabulated results that the problems of cracked grains contributing to low milling yield is more acute in Southern Region whose paddy is milled at Blantyre Rice Mill. Super rice (Head rice with about 5% broken rice in it) recovery at Blantyre Rice Mill declined from 39% in 1979 to 33%, 32% and 30% of corresponding paddy throughput in 1980, 1981 and 1982 respectively while amount of broken rice increased steadily over the same period.

3.2 Discolouration Due to Stack-Burn

Optimum milling yields are achieved in paddy at 13 to 14% moisture content. Any attempt to mill paddy with moisture content above 14% affects the degree of polish and head rice recovery is greatly reduced since wet paddy breaks relatively easily upon milling. Storage of such insufficiently polished rice reduces its storage life considerably due to its high fat content which develops rancidity and an unpleasant odour and taste. To avoid these problems such wet paddy is left in storage to dry slowly in sheds.

During this period of in-shed drying, the top layers may dry to 14% moisture first while the bottom layers are still wet. However, to wait until the bottom layers reach correct moisture content the top will be too dry. Again because of inadequate ventilation the bulk of the paddy generates spontaneous heat due to high moisture in association with high temperatures and relative humidity causing stack-burn (i.e. paddy grains turn a brown colour) which drastically lowers the quality of milled rice because of resultant discolouration. Highly discoloured rice is bitter to the taste and may become toxic and result in digestive disorders.

3.3 Storage Loss

Prolonged storage of wet paddy results in physical and chemical losses caused by metabolism of grain tissues, micro-organisms, insects and mites. Moisture has a profound effect on metabolism of grain tissues, causing spontaneous heating which provides

Table 1. Comparison of Milling Yield Between Noil Rice Mills 1979 – 1982

Mill	Blantyre						Nkhota – Kota					
Year	Through Put	Super Rice		Brokens		Recovery	Through Put	Super Rice		Brokens		Recovery
	Tons	Tons	%	Tons	%	%	Tons	Tons	%	Tons	%	%
1979	5691	2221	39.0	1463	25.7	64.7	5326	2223	41.7	1211	22.7	64.4
1980	7491	2489	33.2	2256	30.1	63.3	8509	3807	44.8	1958	23.0	67.8
1981	8651	2839	32.8	2734	31.6	64.4	4988	1898	38.1	1211	24.3	62.4
1982	2869	865	30.2	984	34.3	64.5	1959	772	39.4	464	23.7	63.1
Total Tonnage	24702	8414		7437			20782	8700		4843		
Average % Yield			34.1		30.1	64.2			41.9		23.3	65.2

Mill	Chilumsa						Kambwe					
Year	Through Put	Super Rice		Brokens		Recovery	Through Put	Super Rice		Brokens		Recovery
	Tons	Tons	%	Tons	%	%	Tons	Tons	%	Tons	%	%
1979	1582	713	45.1	300	19.0	64.1	4750	2706	57.0	363	7.6	64.6
1980	2683	1362	50.8	348	13.0	63.8	6243	3478	55.7	698	11.2	66.9
1981	1417	533	37.6	386	27.3	64.9	4214	2055	48.8	728	17.3	66.1
1982	482	204	42.4	84	17.4	59.8	4376	2069	47.3	719	16.4	63.7
Total Tonnage	6164	2812		1118			19583	10308		2508		
Average % Yield			45.6		18.1	63.7			52.6		12.8	65.4

breeding ground for insects and mites. In addition to losing its viability the free fatty acids increase and the grain loses its natural quality.

4. Drying Experiment

The drying experiment was undertaken in July 1983 at Blantyre Rice Mill which has a Schule Burma Type 11 mill with a capacity of 2 tons per hour. The paddy sample was dried in a Lewis C Grant 8-columns dryer equipped with diesel burners. The paddy passed through the dryer in single pass drying by blowing hot air at 42°C until the moisture content of the paddy dropped to about 13-14%.

4.1 Materials

The variety chosen for the experiment was the Blue Bonnet long grain type paddy because it is grown throughout the irrigation schemes in Malawi. The paddy was bought by ADMARC from small-holder farmers in Southern Region and delivered to NOIL in June. The history of the paddy prior to its arriving at the Blantyre Rice Mill was unknown but it was believed not all the paddy came from one source because levels of chalky, immature, red streaked, rotten grains and other varieties varied considerably in the paddy samples.

4.2 Drying Methods

The paddy samples were dried under three different conditions:–

(a) Heated air drying at 42°C.

(b) Sun-drying. The paddy was spread on a concrete floor under sunlight and stirred regularly. In the evening, the paddy was covered by tarpaulin to prevent absorption of dew at night. This procedure was repeated several days and nights until the paddy was dried to about 13% moisture content. The paddy was bagged and tempered before milling.

(c) Shed-drying in jute bags.

4.3 Milling Results

The paddy at 20.7% moisture content was subjected to three different drying conditions as set out above. After drying samples were analysed and milled both in laboratory and mill to compare their milling yields. Individual lots of dried paddy were milled separately in NOIL rice testing laboratory equipped with a Schule laboratory scale mill. Each paddy sample was analysed and milling yields are recorded in Table 2.

Same lots of dried paddy were also milled separately at Blantyre Rice Mill and milling results are tabulated on Table 3.

4.4 Discussion of Milling Results

(a) Both laboratory and mill results showed that the head rice yield of mechanical and sun-dried paddy are higher than that of paddy dried in shed.

(b) Among the paddy samples dried in different conditions, the hot air dried paddy had the lowest percentage of brokens and sheddried paddy had the highest level of breakage.

(c) The overall milling yields of mechanical and sun-dried paddy are higher than the average recovery rate indicated in Table I. The difference could be as much as 5-6%. This would mean a tremendous increase in terms of economical values of rice produced in Malawi and represents thousands of dollars in foreign exchange earning.

(d) With proper control during drying process, it is very possible to achieve the head rice recovery even above 60% as seen in Table 3 if the paddy is dried in two passes at reduced drying rate.

(e) As far as shed drying is concerned, the paddy would need more time to dry to 13% moisture content. The head rice yield is extremely low when it is milled in the mill because of high moisture content. Shed drying would require that paddy be stacked in small stacks, say 5 layers, and this may require alot of space which may not be available in Malawi with the size of the crop being grown..

Table 2. Laboratory Milling Results

Method of drying	Heated Air at 42°C	Sun	Shed
Initial Moisture Contrent % (w.b)	20.7	20.7	20.7
Final Moisture Content	13.7	13.8	14.6
Drying Period	3 hours	35 hours	32 days
Tempering Period before milling	9 days	7 days	–
Quality of Dried Paddy			
% Chalky Grains	18	20	34
% Cracked Grains	8	8	4
% Immature Grains	4	2	2
% Red Streaked Grains	2	2	1
% Rotten Grains	0	2	1
% Other Varieties	4	4	2
Milling Out-Turn–Laboratory			
% Brown Rice	80.9	81.0	80.5
% Husks	19.0	19.0	19.4
% Milling Yield	70.0	69.0	69.4
% Head Rice	58.8	51.3	50.7
% Broken Rice	11.2	17.7	18.7
% Bran	8.0	9.4	8.5

Table 3. Milling Out-Turn–Mill

Drying Method	Heated Air at 42°C	Sun	Shed
Initial Moisture Content (w.b.)	20.7	20.7	20.7
Final Moisture Content	13.7	13.8	14.6
In-put Weight (kgs)	7198	2172	2246
% Super Grade Rice (5% Brokens)	54.88	55.25	33.39
% Broken	12.50	16.11	26.71
% Willing Yield	67.38	71.36	60.10

5. Solution to the Drying Problem

Emphasis cannot be too strongly laid on the necessity of controlled drying of paddy immediately following harvesting in order to overcome existing quality problems. Following the experimental results, two methods would seem to offer practical solution both to the small scale growers and large scale growers on irrigation schemes.

5.1 Sun-drying

Sun-drying offers small scale growers cheap source of energy to dry their paddy after harvesting. But in order to achieve maximum results, farmers should be advised correct procedure to the effect that paddy whilst being dried in the sun must be regularly stirred in order to expose the paddy to the sunlight uniformly. Excessive exposure to direct sunlight should be avoided in order to minimize incidence of cracked grains. In the evening the paddy should be properly covered to prevent wetting from dew or rain.

5.2 Mechanical Drying

Small type mechanical driers offer practical solution to large scale growers at irrigated schemes. While initial capital investment may be high, mechanical driers would pay for itself in the long run. Mechanical driers permit paddy to be harvested at moisture content above 22% without affecting its desired qualities, making double cropping a year a big possibility thus increasing overall paddy production.

6. Summary and Conclusion

One of the major problems in the rice industry in Malawi is that harvested paddy produces a milled rice with a low head rice yield and high percentage of broken rice. Based on a number of analysis on the different varieties of paddy milled by NOIL in the past, the real cause for high breakage to the grain on milling can be summed up as high percentage of moisture content and of cracked kernels in the paddy before milling. Proper drying is therefore an important aspect in the production of rice if maximum yield of head rice is to be obtained from paddy.

In the interest of the local rice industry, every effort should be made by all concerned to overcome current problems affecting milling yield and quality of milled rice in relation to drying of paddy. Until mechanical driers become a reality in Malawi, sun-drying offers the only solution and paddy growers should be encouraged to sun-dry their paddy properly before offering it for sale. In the meantime, sun-drying procedure should be implemented and reinforced by a price differential as an incentive to growers. When paddy is being bought, prices offered to farmers should correlate with moisture content, the purity of paddy, its maturity and degree of crackedness. In this way, farmers will be encouraged to produce high quality paddy.

7. References

Bhattacharya, K.R. Optimal Agricultural Practices for obtaining the maximum yield of rice from paddy.