COUNTRY REPORT: MALAYSIA

ENHANCING FOOD SAFETY AND SECURITY DURING STORAGE OF PADDY IN MALAYSIA THROUGH THE USE OF AERATION TECHNOLOGY

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Introduction

Maintenance of good paddy quality during long term storage has become one of the major considerations in food security and safety planning and marketing in most developing countries. Failure to comply to good storage management practice can jeopardize food supply chain to the needy population. The lesson learned from the recent rice shortage coupled with souring world as well as domestic prices and rising cost of paddy production have made us wiser on how to handle our sacred commodity.

In Malaysian paddy industry, the drastic changes in policy and market forces, especially during the 90's, have help to expedite the adoption of bulk handling of grain from field to mill complex. The enormous volume, handling and storage cost of paddy can be reduced with the adoption of larger and modern storage systems. Among the modern systems used by the commercial operators in Malaysia for long term storage of dried grain (at 13-14 per cent moisture content – moisture content is always expressed as a wet basis unless otherwise stated) are the vertical concrete and metal tower silos and horizontal bin storage systems.

However, in a hot and humid climate as in the tropics, maintaining good quality of dried paddy during long term storage, particularly in the concrete silos, is a management nightmare. If it is not properly managed, even for a short period of storage, conditions will give rise to undesirable moisture migration and accumulations and hot spots in specific areas within the grain mass followed by mould growth and insect infestation. The inter-granular grain temperature can sometimes rise to as high as 55^{o}C. The outcomes are the loss in paddy quality as a result of grain discoloration and odor and/or total losses as the grain becomes unfit for human consumption. The end result could be catastrophic particularly during periods of food shortage.

The vertical concrete tower silos, each of 750 ton capacity, contributed about 40 per cent of the total government bulk storage capability. Figure 1 shows the typical commercial concrete tower silos of the LPN mill complex without roof. Any improvement in the system would not only improve storage capacity and capability to commercial operators but also contribute to safe guarding national food security and safety.

Silo Storage Practice in Malaysia

At the time grain or paddy reaches physiological maturity, it is considered to be at its prime state in every aspect of its quality. As paddy moved along the post harvest value chain, including storage, it then begins to deteriorate with time, slow at low moisture contents and temperatures but very rapid when they are high.

It is a common practice in commercial practice to store paddy at 14 per cent for periods of at least 6 months or longer to enable milling processes to be carried all year round to ensure adequate supply of rice to the consumers. It is therefore critical to store dried paddy in an environment conducive to the lowest reasonable rate of deterioration.

Safe storage of paddy can take two view points depending on the intended use, as seed, germination and seed viability are paramount. For processing to milled rice for the consumers, rice kernel color, odor and breakages are of prime importance to be minimized to maintain high market grade.

A common practice in Malaysia is to fill the silo structure to about one third or half of its capacity to reduce storage risk and storage period is usually limited to a shorter period; generally about 2 months. During this period, any increase in temperature, in excess of a threshold value, will require grain turning to be carried out. Grain turning is the process of transferring or moving stored grain out from one silo to another silo to break up the hot spots as it comes in contact with the fresh air outside.

Grain turning has its disadvantages; including that it is time consuming and the process affects other operations within the mill. Grain turning is always considered as not a cost-effective operation. A normal grain turning process consumed a total operation time of between 40 to 60 hr, and cost about RM25.50/t. Aeration, a process of bringing fresh and cooler ambient air from outside into the storage structure to be in contact with the warmer stored grain, is considered to be an alternative technique to the cumbersome grain turning to maintain grain quality. As air is moved in between the granular spaces, it breaks up the hot spots, equalizes the temperature and at the same time cooling them. Aeration system may also be used to distribute fumigants through stored rice for insect control during storage.

The earlier concrete silo structures in Malaysia were constructed without any aeration facilities. A research and development was formulated to determine the viability of an aeration technology for paddy stored in concrete tower silo under the prevailing tropical environmental conditions and how it affects the stored quality.

Figure 1. Typical concrete tower silo storage systems with and without out roof

Aeration Design Approach

i. Biological perspective of stored grain

Deterioration of most biological material, even in its dry state, is usually associated with the decomposition of carbohydrates as a result of respiration. The selective respiratory utilization of carbohydrates in grain is assumed to be similar to the oxidative combustion of typical carbohydrates such as hexose sugars (Ramstad and Geddes, 1946). They found that during this biological phase of respiratory behavior of grain, the increased rate of respiration, a symptom of deterioration, was accompanied by a decrease in both reducing and non-reducing sugars. There was however, no change in the fat content during this phase.

The decomposition process results in the loss of dry matter; usually modeled as a breakdown of simple sugars to carbon dioxide, water and heat.

Temperature and moisture content are two physical variables which have been given considerable emphasis in the study of deterioration of grain in storage. The higher the temperature and moisture, the higher is the rate of decomposition and thus the faster is the rate of quality deterioration. With hot humid tropics, there is a very high chance of stored paddy reacting with the ecosystem triggering worst case scenario; total grain loss!

ii. Aeration system design

An aeration system consists of a fan, air supply ducts, aeration ducts (perforated floors) and a fan controller ranging from a simple on-off switch operated manually to a state-of-the-art system. The first step in designing an aeration system is to select a suitable rate of airflow:

a. Airflow rate

Aeration, according to Holman (1960) refers to a process of moving air through stored grain mass at low airflow rate, for propose other than drying. For drying, higher airflow rates of between 0.36 to 1.2 m^3/min/tons or higher is usually used. Steward and Britton (1973) specify a range of airflow rates that can be selected for any condition while Maier (2000) recommended specific airflow rates for different surrounding air conditions.

The selection of a suitable airflow rate however, partly depends on the condition of the paddy, surrounding air temperatures and relative humidity. For aerating slightly undried paddy, a higher airflow rate is required. Aeration generally results in slight additional drying which reduces susceptibility to mold and insect growth.

b. Velocity consideration in the aeration ducts

The device through which air is introduced and distributed into or exhausted from a paddy bin is usually consisted of a round or half-round perforated duct or floor. In the case of aeration system in vertical silo, half-round perforated duct was preferred. Caution needs to be taken so that ducts do not distribute the air evenly through the grain, with the location and spacing of the ducts being critical to ensure uniform or even distribution of aerated air. Two different areas of perforated duct namely the cross-sectional area and the surface area, are important for aeration system design as they require different velocity selection.

Schroeder and Caderwood (1972) established the velocities of air through the cross-sectional area and the surface area for vertical bin and flat bin. Teter (1979), however recommended that for a specified depth, a certain range of air velocity is to be used. As for instance, for a grain depth of less than 5 meters, the velocity through the cross-sectional area should be between 300 to 600 m/min while for grain depth of more than 5 m, the velocity should be between 400 to 900 m/min.

For velocity through the surface area, Teter (1979) also recommended a value of equal or less than 12 m/min, but for shallow bins the preferred velocity should be less than 9 m/min.

c. Fan

Fans, either axial-flow of centrifugal fans, could be used to force air through the system. For work against a high static pressure, a centrifugal fan is normally used as it is more powerful. Power requirement rises rapidly as air flow rates increase and as the depths of the stored grain increase. Some degree of packing occurs as a bin is filled, which increase the pressure drop for any given depth. Shed (1953) tabulated the pressure drops for some grains and seeds, but for typical Malaysian paddy conditions, Maitre Thanswang's (1977) pressure drop for rough rice can be used as it gives a higher value than Shed's. To ensure adequate aeration, therefore, certain requirement of airflow, duct size and arrangement and fan operation must be met.

Field Evaluation of the Aeration System in Concrete Silo Storage Structure

Based on the above recommendations, three airflow rates were selected for comparison in Malaysian conditions to ensure the best airflow rate is chosen for the silo structure; namely 0.3, 0.1 and 0.03 m^3/min/tonne for High (HFR), Medium (MFR) and Low (LFR) respectively. The required duct and fan sizes were determined for the three airflow rates (Table 1).

Table 1. Summary of the LFR, MFR and HFR specifications

No:	Size	LFR	MFR	HFR
1	Duct Diameter, d (m)	0.28	0.4	0.97
2	Length of the duct, L (m)	5.0	5.0 x 2	15 m, along the vertical side (2)
3	Fan power, (HP)	0.5	10.0	10 x 2
4	Volumetric Flow Rate, V (m^3/min)	22.5	75.0	225.0

Three silos were used to evaluate of the relative performance of the three rates of aeration in the first R&D phase. A fourth silo was used as a control. Fresh, clean and dry good quality long grain paddy was used on the trial. As a precautionary measure, silo with LFR was only half full while the MFR and HFR were filled to the full capacity. Paddy samples were taken twice during the duration of the trial; at the beginning and end of the storage for analysis on the moisture content, bulk density, milling yield, germination and microbiological load. Grain, ambient and aeration inlet and exhaust air temperatures were recorded three times a day. Grain turning was carried out if any of the grain temperature sensor point recorded a temperature of 35^{o}C or above for 4 consecutive days.

There was no appreciable change in milling before and after storage in all treatment when comparisons were made using sample milled using laboratory mill, but commercial milling yielded rice of different grades. Higher quality grades can be achieved in the HFR and MFR as compared to the LFR and control; indication that higher airflow rates produced better graded rice (Table 2). LFR showed poor maintenance of rice quality; producing 6.3 per cent sample grade and 8.8 per cent rice of lower grade (A_4) even at half full. Overall, MFR showed a superior grades combination. However, there were differences in the level of discolored grain; LFR (4.2 per cent) higher than MFR (1.7 per cent) and higher than HFR (1.55 per cent). The per cent of discolored kernel was about 2.9 per cent in the control.

Table 2. Rice grades based on commercial milling process (per cent)

Treatment		**Rice Grades**				
		A_1	A_2	A_3	A_4	SAMPLE
1	HFR	6.4	41.7	4.8	-	-
2	MFR	2.2	46.7	2.5	-	-
3	LFR	0.5	36.7	6.5	8.8	6.3
4	Control	-	66.98	-	-	-

Note: A_1 is the highest grade fetching premium price. Sample grade is the lowest grade

The MFR was selected in the second phase for further verification where minor modification was introduced in the duct configuration for uniform air distribution (Figure 2). The study was carried out using two silos at a different rice milling complex for a 6-month storage period (Mohd Nour/Jantan et al., 1993). The results (Table 3 and 4) indicated that the use of an aeration rate of about 0.1 m^3/min/tonne can sustain stored grain quality during long term storage of paddy in concrete silo in Malaysia.

Table 3. Changes in paddy quality during aerated storage

	SILO A		**SILO B**	
	Before storage (0 month)	**After storage (6 month)**	**Before storage (0 month)**	**After storage (6 month)**

Yellow (%)	2.9	2.5	1.9	1.4
Insects damaged (%)	1.80	2.33	1.83	1.37
Moisture (%)	11.3	10.5	11.8	10.8

Table 4. Effect of aerated storage on milling quality

	SILO A		**SILO B**	
	0 month	**6 month**	**0 month**	**6 month**
Head rice (%)	86.0	86.7	83.5	78.0
Broken (%)	14.0	13.3	16.5	22.0
Milling recovery (%)	70.2	71.5	69.9	67.3
Husk (%)	19.7	18.8	18.6	18.7
Bran (%)	9.6	10.3	10.8	13.6

Conclusion

Large-scale storage is an essential component in both food safety and security systems. It can also enhance grain marketing chains. However, maintenance of stored grain quality under large-scale storage system can pose big risk unless measures are taken to address deteriorative changes during storage. The use of aeration is an effective and cheap technique for maintaining grain quality during large-scale and long-term bulk storage of paddy. However, it was not found to be effective against insect growth. Insect control is therefore needed to be integrated in any aeration practices particularly in the tropics. However, the insect activity was not found to be detrimental to the final quality in the first six (6) months of storage period.

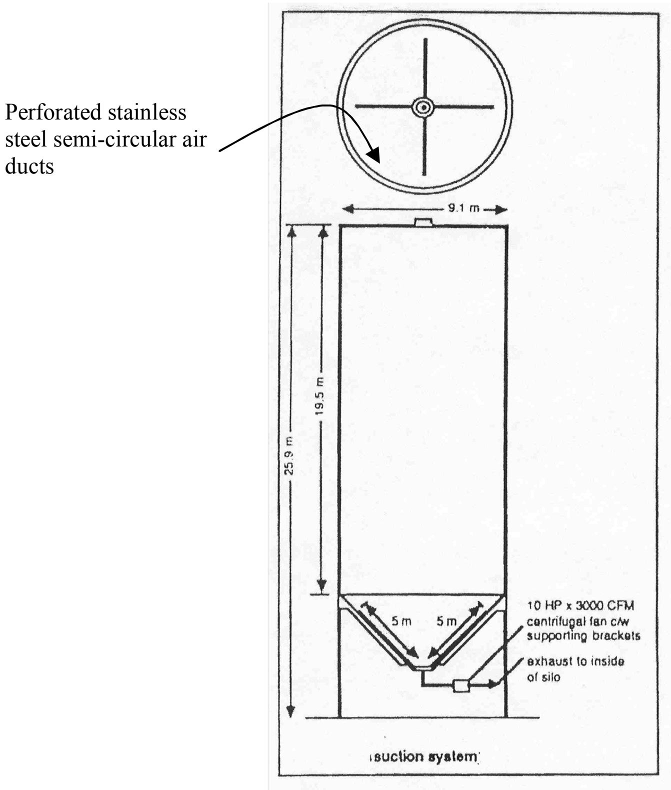

Figure 2. Aeration ducts configuration for the modified MFR (0.1 m^3/min/t)

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