PROJECT NO. RU-6

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2007– December 31, 2007

PROJECT TITLE:

Improvement of Consistency and Accuracy of Rice Sample Milling
- Development of Standard Rice Sample Preparation Procedures

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES

Objectives

1. Quantify the effects of rice sample preparation procedures, such as drying temperature, tempering procedure, storage time after drying, on rice milling quality appraisal.
2. Develop quick rice sample preparation procedure using IR drying.
3. Develop recommendations for rice sample preparation procedures and methods.

Experimental Procedures

<u>Effect of rice sample preparation procedures on rice quality appraisal</u>

Materials and Drying, Tempering and storage Procedures

Californian M202 rice sample with harvest moisture content (MC) of 25.6% (w.b.) obtained from Farmers' Rice Cooperative was used in this study. To create rough rice with different initial moisture contents, the rice sample was split into two large samples. The one of them was laid on the concrete floor to be gradually dried to 21.9% MC at the Food Processing Laboratory in the Department of Biological and Agricultural Engineering, UC Davis. The two MCs are called original MC. The rice samples were dried with air at three different temperatures, 23, 36, and 43°C to 14% from the original moisture (MC).The rice samples dried using air temperature 23 ºC were dried directly from original MC to 14% with one drying pass. When 36°C and 43°C heated air dryings were used, rice samples were dried for 20 min each time and then tempered for 4 hours at ambient temperature. Ambient tempering was conducted by keeping the heated rice samples in room without heating and remained on the drying trays for fours hours. In addition, the rice samples dried with 43°C air was also tempered in an incubator at 43°C, which is called heated tempering. The heated tempering was achieved by transferring the heated rice samples to sealed, insulated containers to prevent heat loss without allowing condensation inside the containers (Fig.1). After tempering, the rice samples were placed back on the air dryer for the next pass drying.

The dried rice samples were stored in Zip-lock plastic bags to prevent moisture absorption during storage. To determine the effect of storage time on the moisture and milling quality of rice samples, rice samples were milled at 1, 2, 3, 4 and 14 days after drying. Two moisture measurement methods were used, standard oven method (130°C, 24 hrs) which is usually used for scientific research purposes and Dickey-John (Auburn, Illinois, U.S.A) which is used for commercial purposes. The moisture contents of original samples and dried samples before milling were measured using both methods. The samples (1000g each) were milled with the McGill No. 3 laboratory mill at California Agri Inspection Co. Ltd (CAICL). The samples were milled using the new standard Rice Milling Procedures and measured milling quality parameters are TRY, HRY, and Whiteness Index. The experimental design is shown in Table 1.

Figure 1. Heated tempering treatments

Table 1. Experimental design for studying effects of drying air temperature and tempering method on rice milling quality

Rice		Ambient tempering	Heated tempering
Original MC (%)	Drying Temperature (°C)		
21.9%	23	No	No
	36	Yes	No
	43	Yes	Yes
25.6%	23	No	No
	36	Yes	No
	43	Yes	Yes

<u>Develop quick rice sample preparation procedure using IR drying</u>

To develop quick rice sample preparation procedure using IR drying, rice samples with tow initial moisture contents of 21.9 % and 25.6% were dried as a single layer for 1, 2 and 3 drying

passes using IR heating. The samples were heated for one min to achieve about 60 ºC at each drying pass under radiation intensity of 5348 W/m^2. After IR heating the samples were tempered at corresponding temperatures in an incubator for 2 hr before slow cooling. Slow cooling was achieved by leaving the rice samples in room on trays under natural cooling till they reached to about room temperature. It took about 35 minutes to reach to about room temperature. This procedure was repeated for each drying pass. After reaching the required number of drying passes, the rice samples were dried to 14% MC with ambient air. The temperature and moisture loss of rice during infrared heating and slow cooling were measured for each drying pass. Control samples were prepared by drying the samples with original moisture contents of 21.9 and 25.6 % using ambient air at 0.1 m/s to final moisture content of 14%.

To determine the effectiveness of infrared heating for rice sample preparation, most important rice milling quality indicators including, total rice yield (TRY), head rice yield (HRY) the and Whiteness index(WI) were evaluated. The rice samples (400 g each) were dehulled and milled using Yamamoto Husker (FC-2K) and Yamamoto Rice Mill (VP-222N, Yamamoto Co. Ltd., Japan). They were milled three times to achieve the well milled rice as defined by the Federal Grain Inspection Service (USDA FGIS, 1994). For the first time, the settings of Throughput and Whitening were 1 and 5, respectively. For the second and third time, the settings were 1 and 4. HRY was determined with Grain checker (Foss North America, Eden Prairie, MN). The Whiteness Index (WI) was used to evaluate degree of milling of milled rice and determined with the Milling Meter, MM1D, (Satake Corporation, Hiroshima 739-8602, Japan).

SUMMARY OF 2007 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVES

<u>Effect of rice sample preparation procedures on appraised milling quality</u>

Moisture change with storage time

In general, the storage time and drying methods did not cause any significant change in measured moisture contents of rice samples during storage up to 14 days after drying (table 2). However, it is clearly observed that the moisture results measured after one day storage time was less than those measured at storage time more than two days. The one day storage time had about 1.25 % and 0.9 % lower moisture compared to storage times more than 2 days. For example, the moisture contents of rice samples with 25.1% original MC dried at 43ºC followed by heated tempering were 13.10 ± 0.17 and 12.77 ± 0.06 after one day and 14.00 ± 0.08 and 12.97 ± 0.06 after two days storage time measured with the oven and DKJ methods, respectively. This could be due to the moisture equilibrium occurred during the storage. However, this phenomenon was not observed in the tests of last year. The moisture measurement results at different storage durations did not show any significant change after 2 days storage time. When these two methods were used for measuring the moisture contents before drying, the results were 25.60 ± 0.10% and 25.07 ± 0.15% for rice with MC level at about 25% and 21.90 ± 0.10% and 21.03 ± 0.06 % for rice with MC level at 21%

measured with oven and DJK, respectively. The maximum difference among the two methods was less than 1.33%. DKJ had lower MC values than oven values. This means that the DKJ need to be carefully calibrated to ensure accurate results of moisture measurement.

Table 2. Moisture contents of rice samples during storage after drying

Original MC content (%)	Drying conditions	MC measurement methods	Storage time(days)				
			1	2	3	4	14
21.9	36 ºC - AT	Oven	13.10± 0.10	14.56 ± 0.10	14.62 ± 0.09	14.75 ± 0.14	14.47 ± 0.10
		DKJ	12.67 ± 0.35	13.03 ± 0.15	13.37± 0.06	13.40 ± 0.00	13.40 ± 0.10
	43 ºC - AT	Oven	13.20 ± 0.20	14.42 ± 0.15	14.58 ± 0.20	14.60 ± 0.20	14.60 ± 0.20
		DKJ	12.97± 0.06	13.10± 0.10	13.30 ± 0.00	13.37 ± 0.06	13.37 ± 0.06
	43 ºC - HT	Oven	13.00 ± 0.20	14.14 ± 0.20	14.30 ± 0.10	14.65 ± 0.30	14.23 ± 0.10
		DKJ	12.53 ± 0.31	12.92 ± 0.06	12.87 ± 0.06	13.07 ± 0.12	13.10 ± 0.10
	AAD	Oven	13.00 ± 0.10	14.19 ± 0.20	14.46 ± 0.10	14.59 ± 0.10	14.46 ± 0.10
		DKJ	12.60 ± 0.26	13.10 ± 0.00	13.17 ± 0.06	13.27 ± 0.06	13.33 ± 0.21
25.6	36 ºC - AT	Oven	13.20 ± 0.10	14.08 ± 0.07	14.10 ± 0.30	14.38 ± 0.03	14.10 ± 0.20
		DKJ	12.63 ± 0.06	12.90 ± 0.10	13.03 ± 0.06	13.17 ± 0.15	13.13 ± 0.12
	43 ºC - AT	Oven	13.4 ± 0.20	14.10 ± 0.17	14.30 ± 0.13	14.56 ± 0.10	14.20 ± 0.10
		DKJ	12.70 ± 0.17	12.93 ± 0.06	13.07 ± 0.06	13.23 ± 0.06	13.20 ± 0.17
	43 ºC - HT	Oven	13.10 ± 0.17	14.00 ± 0.08	14.20 ± 0.15	14.40 ± 0.20	14.10 ± 0.10
		DKJ	12.77 ± 0.06	12.97 ± 0.06	13.03 ± 0.06	13.17 ± 0.06	13.17 ± 0.15
	AAD	Oven	13.00 ± 0.20	13.90 ± 0.01	13.95 ± 0.07	14.10 ± 0.05	14.00 ± 0.01
		DKJ	12.60 ± 0.10	12.98 ± 0.10	12.97 ± 0.06	13.07 ± 0.06	13.03 ± 0.06

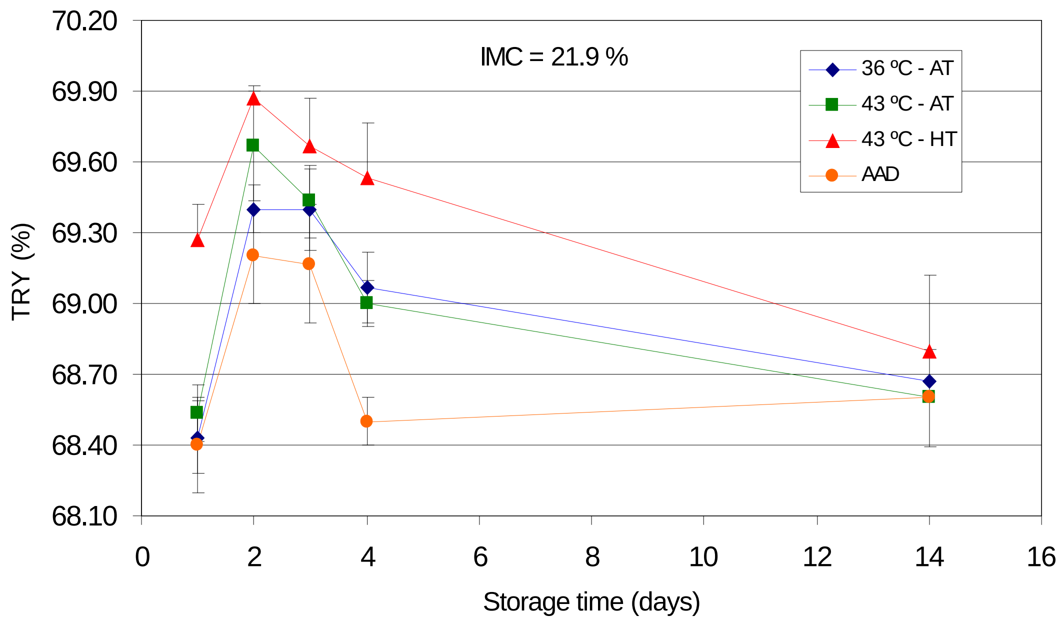
AT=ambient tempering, HT= heated tempering, and AAD=ambient air drying

Milling quality change with drying temperature, tempering and storage time

The milling quality results of rice samples prepared with different drying temperatures, tempering methods and storage times are shown in Figs 2-4. In general, the variation of TRY was in a very narrow range of less than 1.5%. However, both the high and low MC rice samples dried at 43 ºC followed by heated tempering had higher TRY compared to the other drying and tempering procedures. For example, TRY of low MC rice samples dried at 43°C with heated tempering and then milled two days after drying was 69.87% compared to 69.67 % (43°C plus ambient tempering), 69.40 % (36°C plus ambient tempering), and 69.20% (ambient air drying). For all drying and tempering procedures, maximum TRY values were achieved when the rice was milled two days after drying.

HRY varied in a wider range compared to TRY. Similar to TRY, maximum HRY occurred after two days of storage (Fig.3a). HRY of low MC rice samples dried at 43°C with heated tempering and then milled two days after drying was 65.83% compared to 64.23 % (43°C plus ambient tempering), 64.97 % (36°C plus ambient tempering), and 65.13% (ambient air drying). It is significantly higher than the HRY of rice samples dried at 36 ºC and 43ºC followed by ambient tempering (Table 3). But it is not significantly from the HRY of rice dried with ambient air.

It is unexpected that after two days of storage, the TRY and HRY decreased and HRY generally stabilized at slightly higher levels after three days of storage compared to the results from one day of storage. Compared the results from last year, the less effect of storage time on HRY obtained this year could be due to the new milling procedure with lower milling weight.



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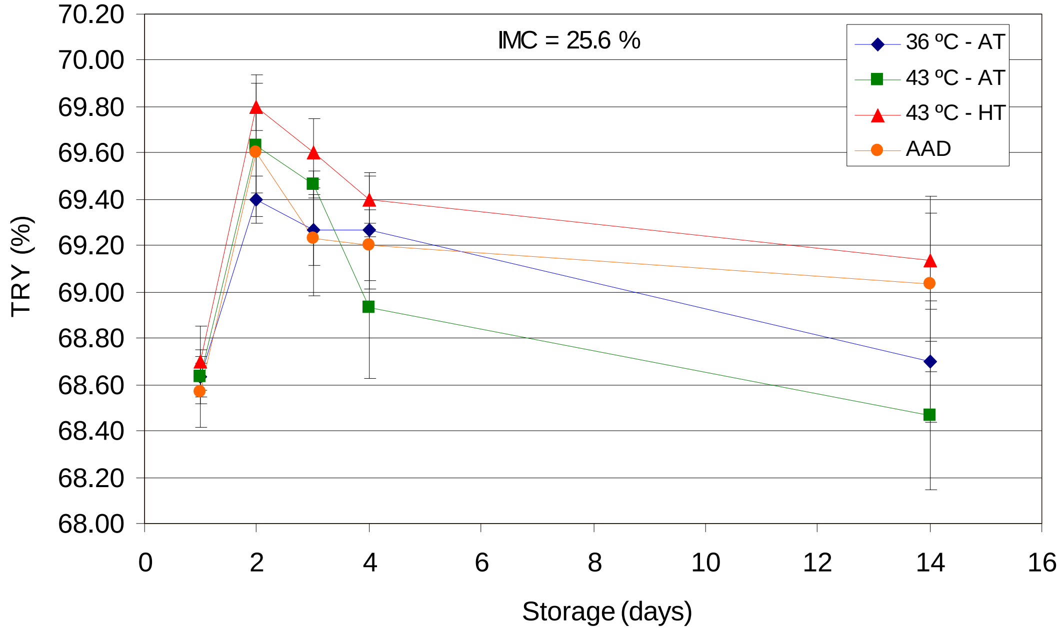
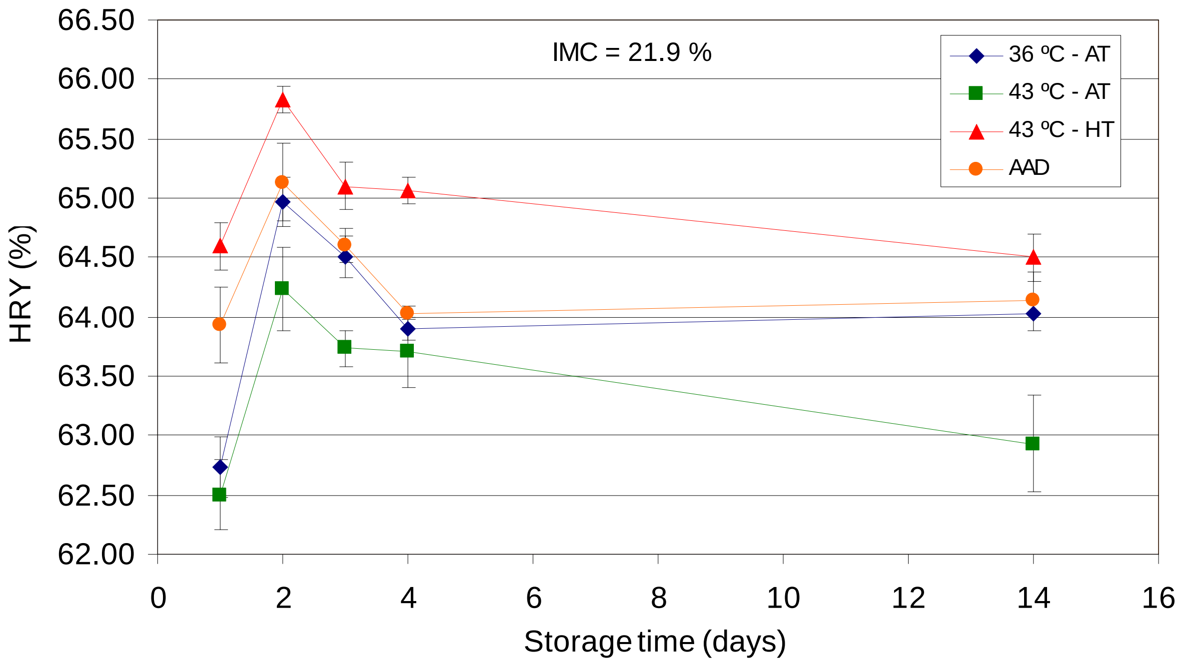


(b)

Figure 2. Effect of storage time on total rice yield of rice with different drying temperatures and tempering procedures (a) MC=21.9%; (b) MC = 25.6%



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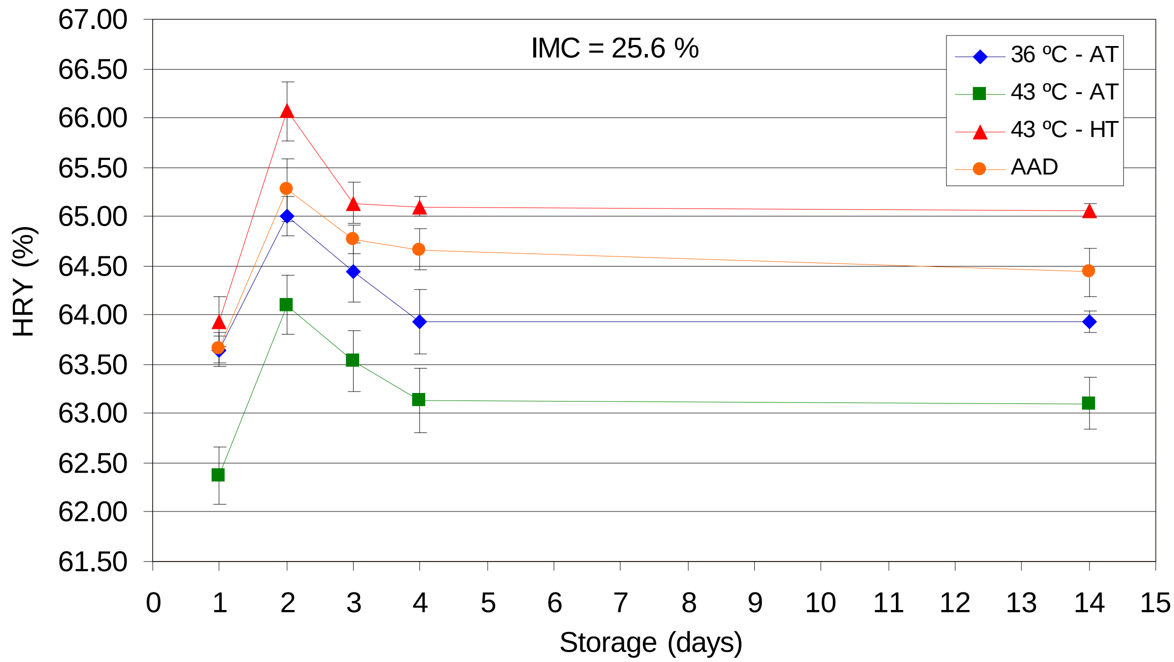


(b)

Figure 3. Effect of storage time on head rice yield of rice with different drying temperatures and tempering procedures (a) MC=21.9%; (b) MC = 25.6%

Table 3. Milling quality of rice with different drying and tempering procedures

Original MC (%)	Storage time (days)	Drying and tempering procedures[a]	Quality of milled rice[b]		
			TRY	HRY	WI
21.9	1	36 ºC – AT	68.43 ac	62.73 a	40.17 a
		43 ºC – AT	68.37 ac	62.50 a	40.20 a
		43 ºC – HT	69.27 b	64.60 bc	40.67 a
		AAD	68.50 c	63.93 bc	40.80 a
	2	36 ºC – AT	69.40 ab	64.97 ab	40.13 a
		43 ºC – AT	69.67 a	64.23 a	40.07 a
		43 ºC – HT	69.87 a	65.83 b	40.23 a
		AAD	69.20 b	65.13 b	40.83 b
	3	36 ºC – AT	69.40 ab	64.50 ad	40.00 a
		43 ºC – AT	69.43 ab	63.73 b	40.33 a
		43 ºC – HT	69.60 a	65.10 c	40.43 a
		AAD	69.17 b	64.60 d	41.00 b
	4	36 ºC – AT	69.07 ab	63.90 ac	40.00 a
		43 ºC – AT	69.00 ab	63.70 ac	40.06 a
		43 ºC – HT	69.43 a	65.00 bc	40.03 a
		AAD	68.60 b	64.00 c	40.02 a
	14	36 ºC – AT	68.67 a	64.03 a	40.10 a

		43 ºC – AT	68.60 a	62.93 b	40.00 a
		43 ºC – HT	68.67 a	64.50 a	40.03 a
		AAD	68.73 a	64.13 a	40.27 a
25.6	1	36 ºC – AT	68.63 a	63.63 a	40.23 a
		43 ºC – AT	68.63 a	62.37 b	40.50 a
		43 ºC – HT	68.70 a	63.93 a	40.13 a
		AAD	68.57 a	63.67 a	40.60 a
	2	36 ºC – AT	69.40 a	65.00 a	40.17 a
		43 ºC – AT	69.63 a	64.10 ac	40.07 a
		43 ºC – HT	69.80 a	66.07 bc	40.03 a
		AAD	69.60 a	65.27 c	41.03 b
	3	36 ºC – AT	69.27 a	64.43 ad	40.13 a
		43 ºC – AT	69.47 a	63.53 b	40.16 a
		43 ºC – HT	69.60 a	65.13 cd	40.03 a
		AAD	69.23 a	64.77 d	40.97 b
	4	36 ºC – AT	69.30 a	63.93 a	40.13 a
		43 ºC – AT	69.00 a	63.13 b	40.03 a
		43 ºC – HT	69.40 a	65.10 c	40.00 a
		AAD	69.00 a	64.67 c	40.37 b
	14	36 ºC – AT	68.70 a	63.93 ad	40.03 a
		43 ºC – AT	68.47 a	63.10 b	40.13 a
		43 ºC – HT	69.13 a	65.07 c	40.00 a
		AAD	69.03 a	64.43 d	40.36 b

[a] AT = ambient tempering, HT = heated tempering, AAD = ambient air drying
[b] TRY = total rice yield, HRY = head rice yield, and WI = whiteness index. Values in each storage time with the same letter indicated no significant difference among the different drying and tempering treatments at $p<0.05$

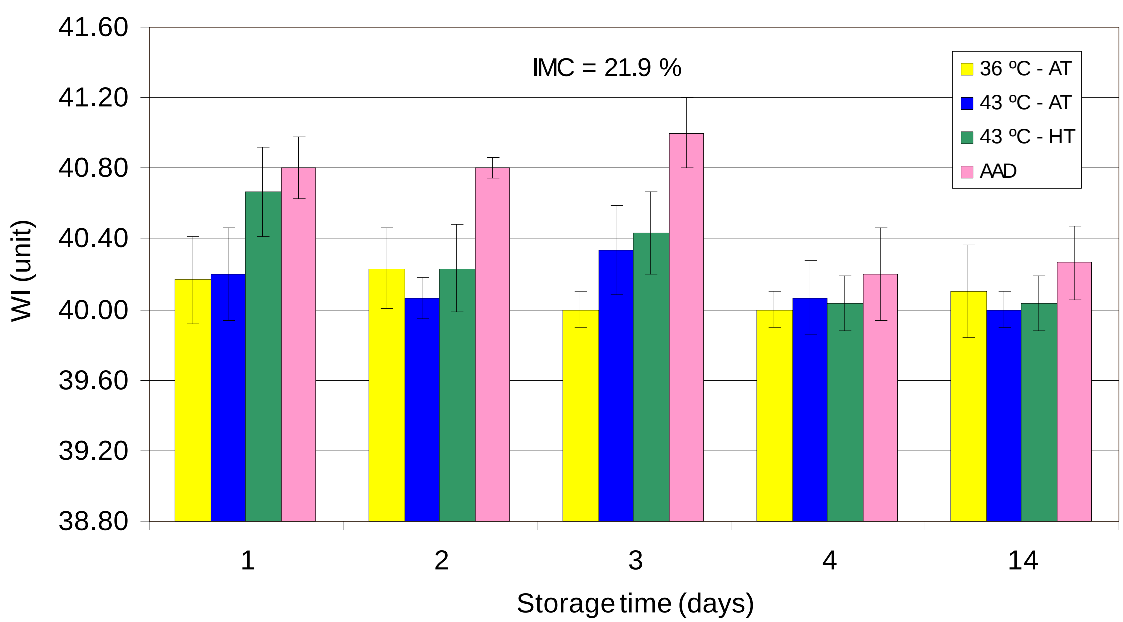
Table 4. Milling quality of rice with different storage times

Original MC (%)	Drying and tempering procedures[a]	Storage time (days)	Quality of milled rice[b]		
			TRY	HRY	WI
21.9	36 ºC - AT	1	68.43 ac	62.73 a	40.17 a
		2	69.40 b	64.97 b	40.13 a
		3	69.40 b	64.50 c	40.00 a
		4	69.06 bc	63.90 d	40.00 a
		14	68.67 c	64.03 d	40.10 a
	43 ºC - AT	1	68.37 ad	62.50 ac	40.20 a
		2	69.67 b	64.23 b	40.07 a
		3	69.43 bc	63.73 bc	40.33 a
		4	69.00 cd	63.70 bc	40.07 a
		14	68.60 d	62.93 ac	40.00 a
	43 ºC - HT	1	69.27 a	64.60 acd	40.67 a
		2	69.87 b	65.83 b	40.23 a
		3	69.60 abc	65.10 c	40.43 a
		4	69.43 ac	65.07 c	40.03 a
		14	68.67 d	64.50 d	40.03 a
	AAD	1	68.50 ac	63.93 a	40.80 a
		2	69.20 bc	65.13 bc	40.83 ac

		3	69.17 bc	64.60 abc	41.00 ab
		4	68.96 abc	64.03 c	40.20 ac
		14	68.73 c	64.13 ac	40.27 ac
25.6	36 ºC - AT	1	68.63 ac	63.63 a	40.23 a
		2	69.40 b	65.00 bc	40.17 a
		3	69.27 b	64.43 cd	40.13 a
		4	69.27 b	63.93 d	40.13 a
		14	68.70 c	63.93 ad	40.03 a
	43 ºC - AT	1	68.63 a	62.37 a	40.50 a
		2	69.63 b	64.10 b	40.06 a
		3	69.47 bc	63.53 bc	40.16 a
		4	68.93 abc	63.13 ac	40.03 a
		14	68.47 ac	63.10 ac	40.13 a
	43 ºC - HT	1	68.70 ac	63.93 a	40.13 a
		2	69.80 b	66.07 b	40.03 a
		3	69.60 b	65.13 c	40.03 a
		4	69.40 bc	65.10 c	40.00 a
		14	69.13 c	65.07 c	40.00 a
	AAD	1	68.57 a	63.67 a	40.60 ad
		2	69.60 b	65.27 b	41.03 a
		3	69.23 b	64.77 bc	40.97 ab
		4	68.97 ab	64.67 bc	40.37 c
		14	69.03 ab	64.43 c	40.37 c

[a] AT = ambient tempering, HT = heated tempering, AAD = ambient air drying
[b] TRY = total rice yield, HRY = head rice yield, and WI = whiteness index. Values in each drying and tempering treatment followed by a same letter indicated no significant difference among the different storage times at $p<0.05$

The whiteness of rice samples dried with ambient air was slightly higher than that of samples produced with the other drying and tempering procedures, but, generally, no significant difference was observed (table 3, 4). The storage time also did not affect the whiteness, the results were similar to the results we obtained last year.



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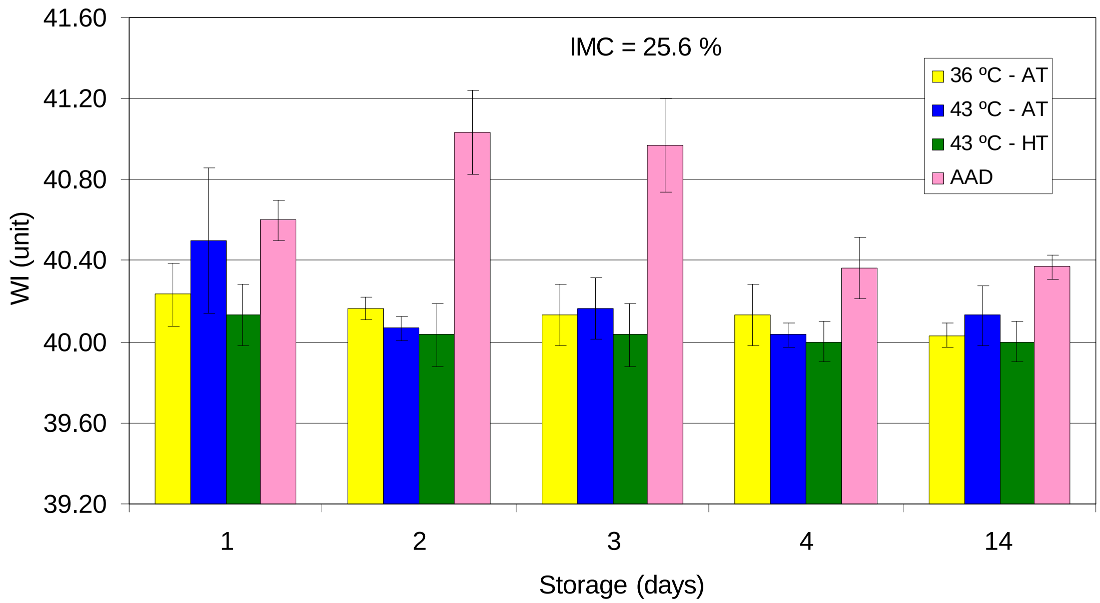


(b)

Figure 4. Effect of storage time on whiteness index at different drying temperatures and tempering procedures (a) MC=21.9%; (b) MC = 25.6%

Total moisture removal percentages during different drying passes are shown in table 5. When the moisture removal at each drying pass was examined, for the treatment of 43 ºC drying followed by heated tempering, it took only five and sex drying passes to reach to about 14% MC for the rice samples with original MC of 21.9% and 25.6%, respectively. When the drying temperature was lowered, the required drying passes increased. For the treatment of 36ºC drying followed by ambient tempering, it took seven and nine drying passes to reach to MC of 14 % for rice samples with original MC of 21.9% and 25.6%, respectively. It has also observed that it took 9 and 14 hours to dry the rice with 21.9% and 25.6% original MC to about 14 % with ambient air drying.

It is important to notice that high TRY and HRY were achieved with less drying passes under 43 ºC drying followed by heated tempering. Heated tempering is very important at each drying pass to reestablish the moisture equilibrium in rice kernels and improve moisture removal and rice milling quality. However, it is not know if the heated tempering time of 43 ºC drying can be reduced, which could further reduce the required total sample drying time.

Table 5. Moisture removal during different drying passes

Original MC (%)	Drying and tempering procedures	Drying passes and total moisture removal (%)								
		1	2	3	4	5	6	7	8	9
21.9	36 ºC - AT	1	1.9	1.8	1.5	1	0.4	0.3		
	43 ºC - AT	2	2	1.9	1.3	1	0.6			
	43 ºC - HT	2	2.2	1.7	1.5	1.1				
25.6	36 ºC - AT	1	1.9	2	1.6	1.3	1.1	1	0.6	0.5
	43 ºC - AT	2	2.16	2.1	1.84	1.7	1.52	0.45		
	43 ºC - HT	2	2.5	2.2	2.1	1.7	1.4			

Quick rice sample preparation procedure using IR drying

The temperatures, moisture removals and milling quality (TRY, HRY and WI) of rice samples with different IR drying passes are shown in Figs. 5-9. When the rice samples with original MC of 21.9 % were heated for 60 s at each drying pass, they reached to temperatures of 60.3, 62.03 and 64ºC during first, second and third drying pass, respectively. The corresponding moisture removals during infrared heating were 1.32, 1.07 and 0.75 percentage and total moisture removals, after slow cooling, were 3.11, 2.3 and 1.61 percentage points. The TRY were 69.02%, 68.44% and 67.42% for the samples dried with one, two and three passes, respectively. The results with one and two IR drying passes were 1.98 and 0.91 percentage points significantly higher than the control dried with ambient air (table 6). Similarly, the HRY were 64.78%,63.70% and 60.02% for the rice dried with one, two and three drying passes, respectively. The results with one and two passes were 1.33 and 0.25 percentage points significantly higher than the control.

When the rice samples with original MC of 25.6 % were heated for 60 s at each drying pass, they reached to temperatures of 58.3°C, 60.04°C and 61.7 ºC during first, second and third drying passes, respectively. The MC removals during infrared heating were 1.86, 1.27 and 0.97 percentage points during first, second and third drying passes, respectively. The corresponding total MC removals, after slow cooling, were 3.9, 3.27 and 2.32 percentage points. As expected, the more moisture was removed for high MC rice compared to low MC rice.

The TRY were 69.04%, 69.24% and 69.83% for rice dried with one, two and three IR drying passes, respectively. The results were 1.63, 1.83 and 2.42 percentage points significantly higher than the control (table 6). Similarly, the HRY were 64.18%, 64.19% and 65.11% for rice dried with one, two and three passes, respectively, which were 1.05, 1.06 and 1.28 percentage point significantly higher than the control. It seems that TRY and HRY decreased with increase of drying passes for low MC rice and increased with increase of drying passes for high MC rice. It is not clear why the TRY and HRY increased with the increase of number of passes. The whiteness of rice samples dried with IR was slightly lower than control.

Based on above results, it can be concluded that milling quality was not affected for low MC rice with two drying passes or high moisture with three passes. The two and three drying passes removed 5.4 and 9.5 percentage points of MC for the low and high MC rice respectively. After the IR drying, the moisture contents were 17.5% and 16.1%, which is close to 14% which is required for rice milling. The results indicated that rice milling samples can be prepared by using IR drying with much reduced drying time. Since the rice was heated to 60°C and tempered at 60°C, the tempering time may be reduced from the 2 hours we have used.

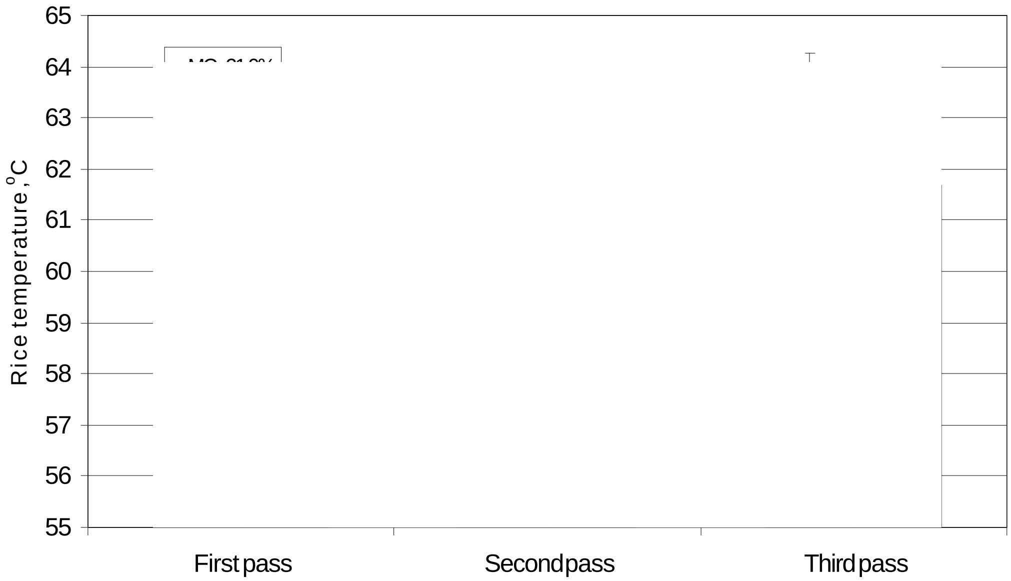


Figure 5. Rice temperatures during drying passes under IR heating for one minute and radiation intensity of 5348 W/m^2

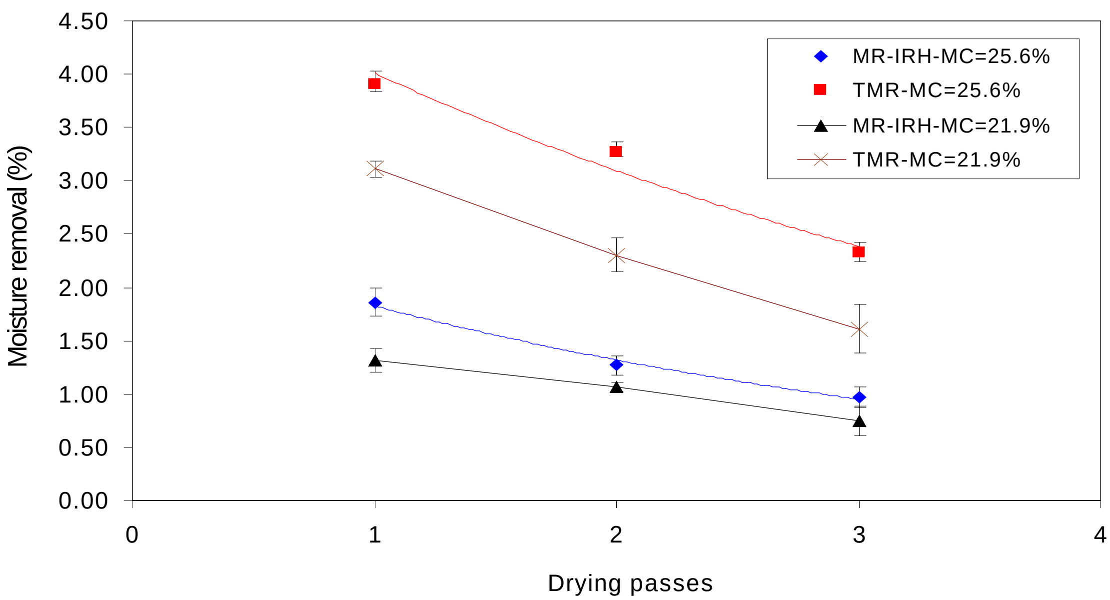


Figure 6. Moisture removals of rice during IR drying passes
(MR – Moisture removal, IRH – Infrared heating, TMR – total moisture removal)

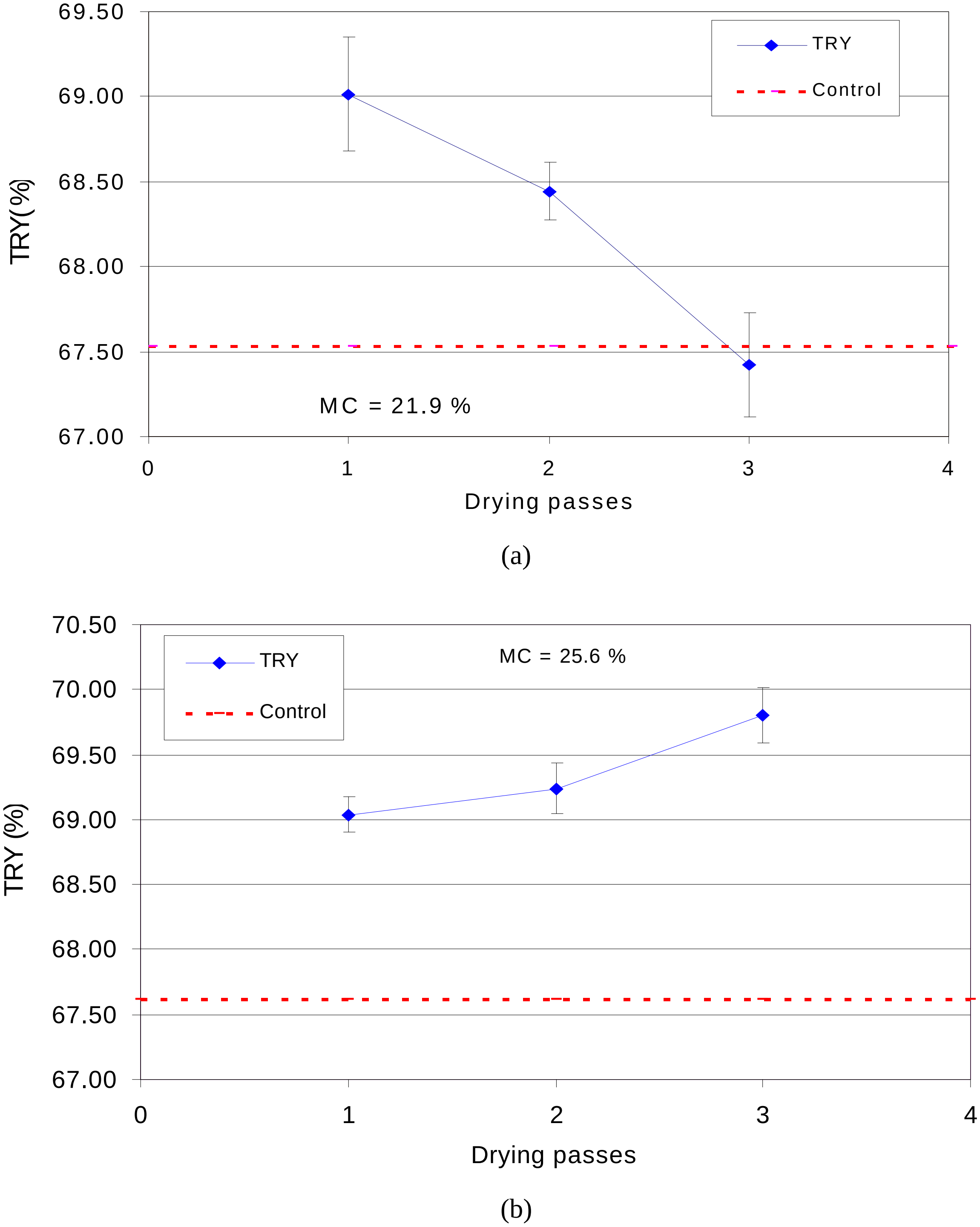
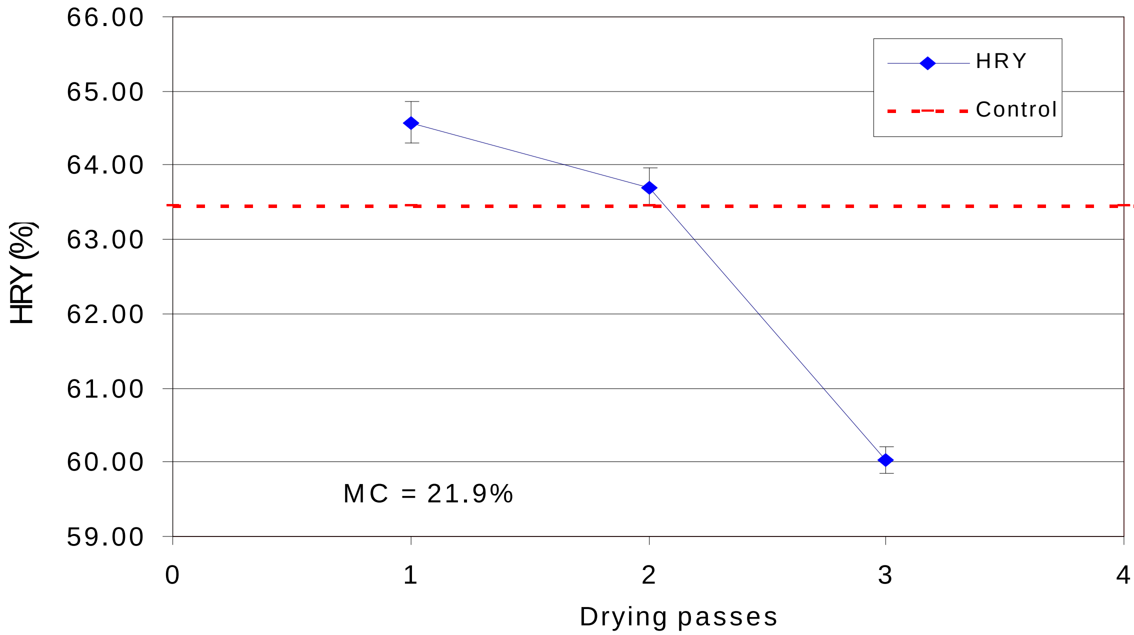


Figure 7. Total rice yield of rice with different IR drying passes
(a) MC=21.9%; (b) MC = 25.6%



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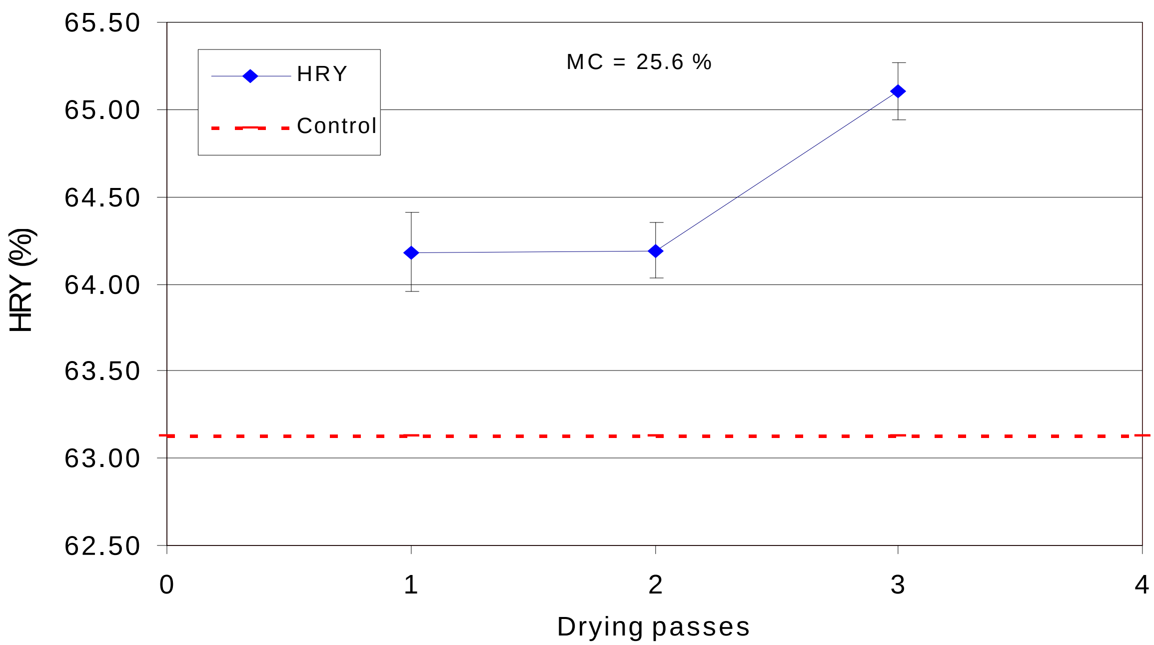
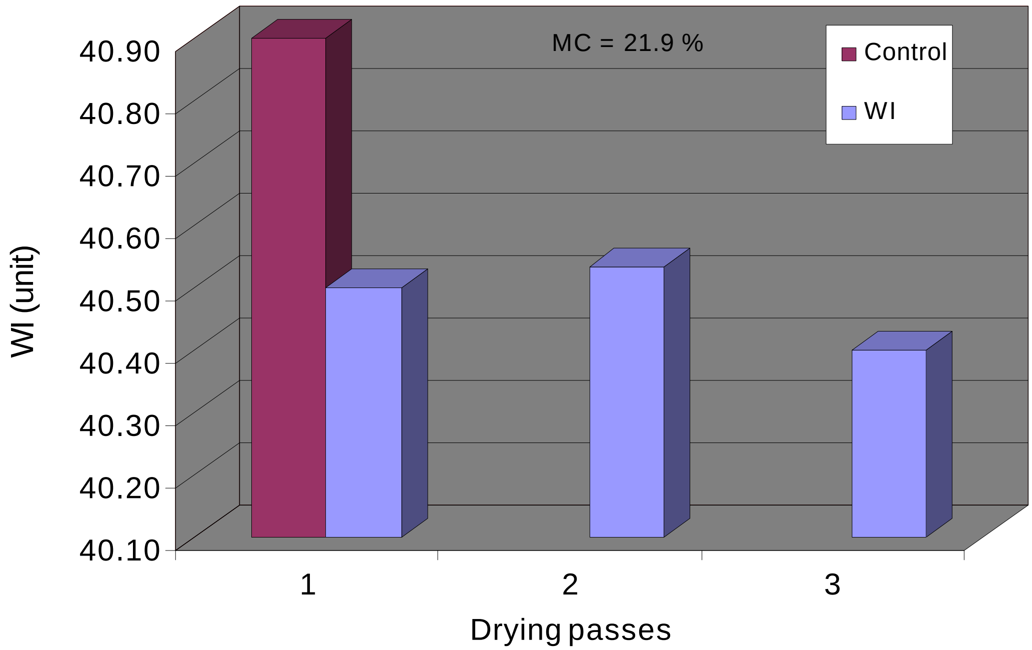
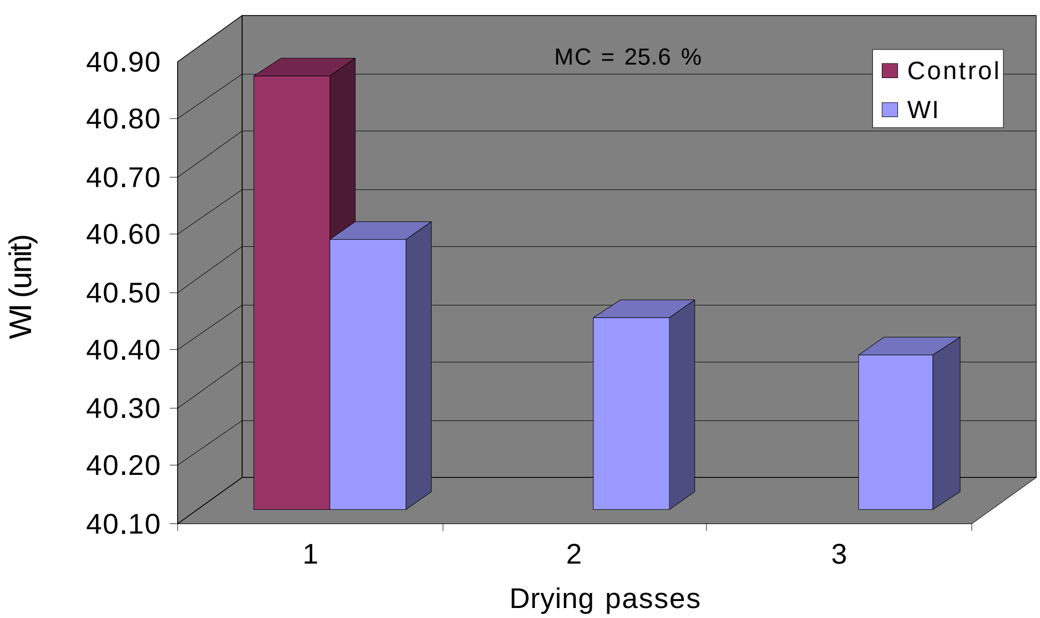


(b)

Figure 8. Head rice yield of rice with different IR drying passes
(a) MC=21.9%; (b) MC = 25.6%



(a)



(b)

Figure 9. Whiteness index of rice with diffent IR drying passes
(a) MC=21.9%; (b) MC = 25.6%

Table 6. Milling quality of rice with different IR drying passes

Original MC %	IR drying pass	Rice milling quality		
		TRY	HRY	WI
21.9	One	69.01 a	64.78 a	40.50 a
	Two	68.44 a	63.70 b	40.53 a
	Three	67.42 b	60.02 c	40.40 a
	Control	67.53 b	63.45 b	40.90 b
25.6	One	69.04 a	64.18 a	40.50 a
	Two	69.24 a	64.19 a	40.47 a
	Three	69.83 b	65.11 b	40.30 a
	Control	67.41 c	63.13 c	40.90 b

TRY = total rice yield, HRY = head rice yield, and WI = whiteness index. Values in each category followed by a same letter indicated no significant difference between IR drying passes at $p<0.05$

Recommendations

Based on the research results from the last two years, below are recommendations for rice sample preparation.

1. Rice sample should be stored for at least two days before milling.
2. Rice sample should not experience dramatic RH change during storage.

PUBLICATIONS OR REPORTS

N/A

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

The research in this report focused on two objectives. One was to quantify the effects of rice sample preparation procedures, such as drying temperature, tempering procedure, storage time after drying, on rice milling quality appraisal. Another one was to develop quick rice sample preparation procedure using IR drying.

For achieving the first objective, the rice samples with two original MC of 21.9% (low) and 25.6% (high) were dried to 14% MC with air at three different temperatures, 23, 36, and 43°C. The rice samples (control) were dried to 14% MC with one pass when 23°C air was used. The rice samples dried using air at 36°C and 43°C were dried for 20 min each time and followed by ambient tempering for 4 hours. In addition, the rice dried with 43°C was also tempered in a 43°C incubator. The rice samples were milled with the new standard rice milling procedure after they were stored for 1, 2, 3, 4 and 14 days. Rice dried with 43 ºC air followed by heated tempering had higher milling quality compared to the other drying and tempering procedures. The maximum HRY values were achieved when the rice was milled two days after drying. The milling quality was stabilized slightly higher level compared the rice milled with one day of storage. The whiteness of rice samples dried with ambient air was slightly higher than the other drying and tempering procedures, but no significant difference was observed. It is suggested that rice should be stored at least two days to avoid the negative effect of storage time on appraised milling quality.

To develop quick rice sample preparation using IR drying, rice samples with two initial moisture contents were dried as a single layer using IR heating up to three drying passes. The samples were heated for one minute to achieve about 60 ºC. After IR heating the samples were tempered at corresponding temperatures in an incubator for 2 hr before slow cooling. After reaching the required number of drying passes, the rice samples were dried to 14% MC with ambient air. The milling quality was not affected for low MC rice with two drying passes or high moisture with three passes. The two and three drying passes removed 5.4 and 9.5 percentage points of MC for the low and high MC rice respectively. After the IR drying, the moisture contents were 17.5% and 16.1%, which is close to 14% which is required for rice milling. The results indicated that rice milling samples can be prepared by using IR drying with much reduced drying time. Since the rice was heated to 60°C and tempered at 60°C, the tempering time may be reduced from the 2 hours we have used.

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