PROJECT NO.__RU-6___

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2004 – December 31, 2004

PROJECT TITLE:

Improvement of Consistency and Accuracy of Rice Sample Milling

PROJECT LEADER:

Zhongli Pan
USDA ARS WRRC
800 Buchanan St.
Albany, CA 94710

PRINCIPAL UC INVESTIGATORS:

Zhongli Pan
USDA ARS WRRC

James F. Thompson
Department of Biological and Agricultural Engineering
University of California - Davis

COOPERATORS:

Homer Formentera
Dale A. Rice
Michael Johnson
Chuck Britton
Sandra Newell

LEVEL OF 2004 FUNDING: $23,000

OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

Objectives

The ultimate goal of this research project was to develop a new milling procedure/method for improving the consistency and accuracy of rice sample milling. The research results are expected to lead to minimizing the Californian rice producers' economic loss caused by milling yield variation due to the high milling temperature in rice sample milling. For current year's research, the specific objectives were:

1. Determine the effects of different cooling methods on quality appraisal results of California paddy rice with different qualities; Compare the quality appraisal results obtained with standard Western and Southern FGIS procedures.
2. Study the quality appraisal results of Southern rice milled with the Western and Southern milling procedures.
3. Develop recommendations for modifying the current rice sample milling procedures to improve the consistency and accuracy of milling results.

Experimental Procedures

Materials and Milling Procedures

Three Californian M202 rice samples with different qualities (high, medium and low), were used for this study. The rice samples were obtained from Farmer's Rice Co-operatives. The moisture contents were 12.6%, 13.1 %, and 12.9% for low, medium and high quality rice, respectively. One medium paddy rice sample with 10.2% moisture content was obtained from the Agricultural Experiment Station of Louisiana State University. The samples (1000g each) were milled with McGill No. 3 laboratory mill (Fig. 1) at CDFA Lab under various conditions with and without cooling following the standard Western milling procedures (10 pound weight for milling and 2 pound weight for polishing) of Federal Grain Inspection Service (FGIS). The rice samples were also milled using the standard Southern milling procedures (8 pound weight for milling and 0 pound weight for polishing). The rice samples from the southern region were milled using both the standard Western and Southern milling procedures.

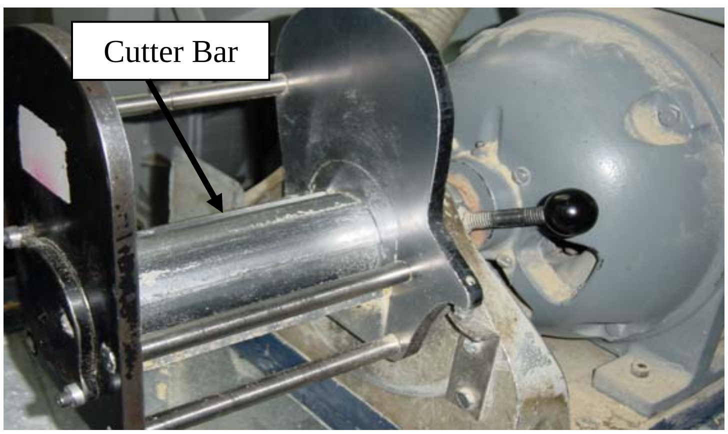


Fig. 1 McGill No.3 rice sample mill and location of cutter bar temperature measurement

Cooling Methods

The current milling practice at CDFA is to cool the cutter bar to 48-52°C (115 -130°F) using a fan before a new rice sample is milled. The temperature of cutter bar prior to the start of milling was named as initial cutter bar temperature in this study. After rice is milled and unloaded from the rice mill, the temperature of cutter bar was measured again and named as ending cutter bar temperature. Both initial and ending cutter bar temperatures were measured using an infrared temperature meter.

To reduce the milling temperature (including rice and equipment temperatures) during milling, two external and internal cooling devices were developed in the previous year. They were named as saddle and cutter bar heat exchangers, respectively. The cooling medium was pumped through the heat exchangers during the milling process. Both the internal and external cooling devices (heat exchangers) were used for the milling study. The milling quality results of the California medium paddy rice samples were compared after the rice samples were milled under various conditions, including control (no cooling), internal cooling only, external cooling only, and combination of internal and external cooling. Ice water and water at ambient temperature were used as cooling media. The experimental set up of the cooling tests is shown in Fig 2.

When it was used, the external heat exchanger added additional weight to the milling chamber. Therefore, the weight load of mill was adjusted to keep the milling pressure to be the same as the current standard milling practice at the CDFA lab. The temperatures of cooling medium, milled rice, and cutter bar were measured before and after milling.

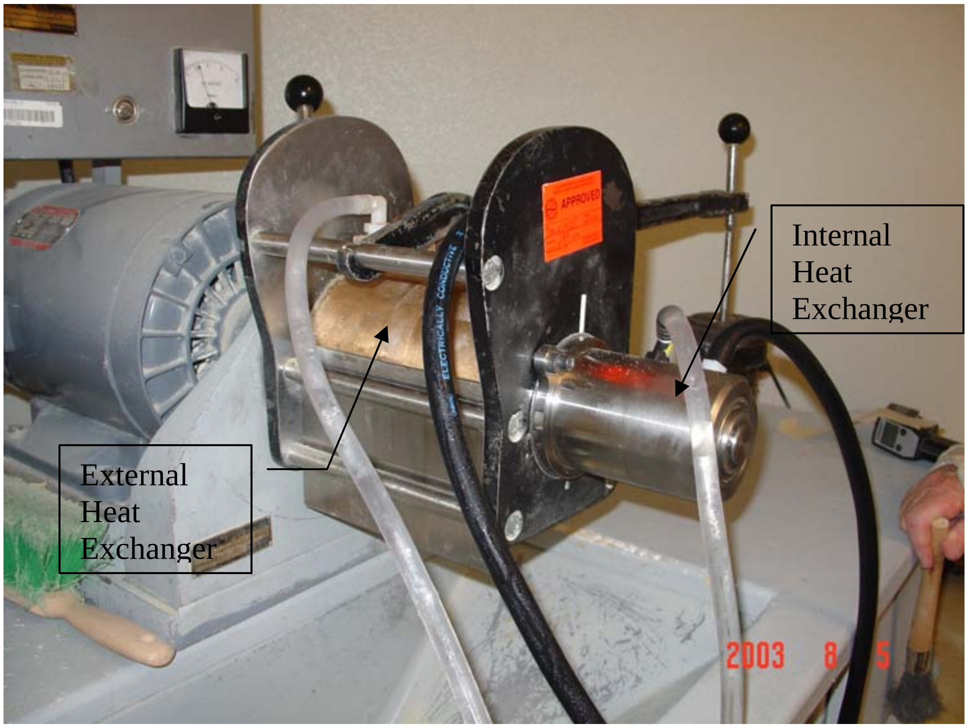


Fig. 2 Set-up of internal and external heat exchangers

Experimental Design of Milling Test

The effects of cooling methods and milling procedures on quality appraisal results were studied following the experimental design shown in Table 1. The ambient temperature was in the range of 68-70°F. The ice water temperature was in the range of 34-38°F. For the milling tests without cooling, the initial cutter bar temperature was control at about 120°F and measured at each of the tests. The initial cutter bar temperatures were set at 75°F and 55°F, respectively, when room temperature water and ice water cooling tests were used. The initial and ending cutter bar temperatures were measured and reported.

Table 1. Experimental design for studying effects of milling conditions

Rice		Southern milling procedure	Western milling procedure (Control)	Western milling procedure with different cooling conditions				
				CB-Water	CB-Ice	CB+Sad-Water	CB+Sad-Ice	Sad-Ice
California M202	High quality (HQ)	x	X	X	X	X	X	X
	Medium quality (MQ)	X	X	X	X	X	X	X
	Low quality (LQ)	X	X	x	x	x	x	X
Southern medium grain		x	X					

Notes: CB – cutter bar heat exchanger; Water – water at room temperature, Sad – saddle heat exchanger; Ice – ice water

Measurement of Milled Rice Quality

The evaluated quality indicators included total rice yield (TRY), head rice yield (HRY), and Whiteness Index (WI). The WI was used to evaluate the whiteness of milled rice determined with Whiteness Tester, C-300, (Kett Electronic Laboratory, Tokyo, Japan). A higher the index number indicates a whiter milled rice.

SUMMARY OF 2004 RESEARCH (MAJOR ACCOMPLISMENTS) BY OBJECTIVES

Effects of different cooling methods on quality appraisal results of California paddy rice with different qualities; Compare the quality appraisal results obtained with standard Western and Southern FGIS procedures

TRY, HRY and WI

It is very clear that regardless of the milling temperature, the HRYs were closely related to TRYs even though the relationships were different for rice samples of different quality (Fig. 3). Meanwhile, the TRYs and HRY were affected by the milling conditions (Figs. 4 and 5). In general, the TRY and HRY were improved with the increase of the degree of cooling. The milling tests with cooling significantly increased the TRYs and HRYs. The HRYs of high quality rice, medium and low quality rice were improved by 1.2-2.6%, 1.2-2.6%, and 2.2-4.3%, respectively. The combination of Sad and CB heat exchangers with ice water had the highest TRY and HRY. This proved that cooling methods we developed were effective in improving the milling quality results. At the same time, the results may also indicate that the sample milling with the cooling may bring the quality appraisal results inline with the current commercial milling operations which use relatively low milling temperature.

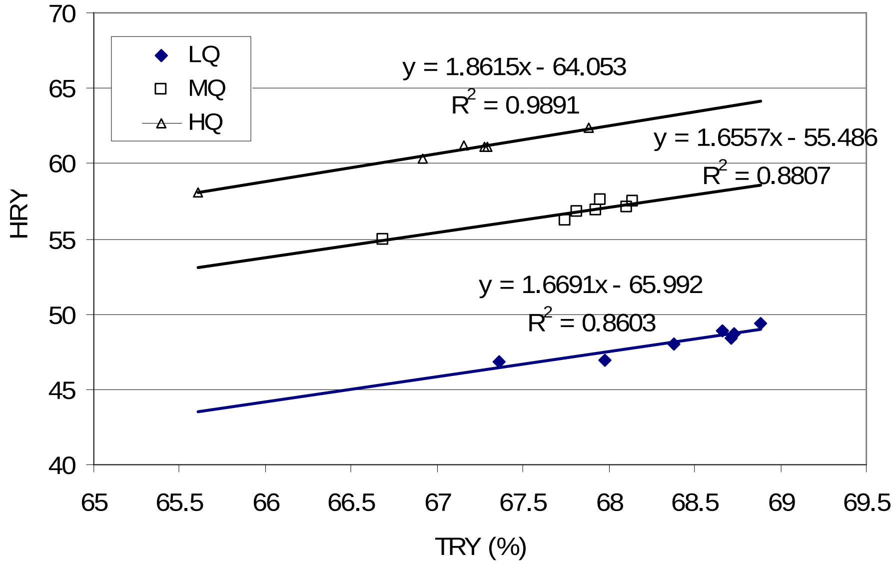


Fig. 3 Relationship between head rice yields and total rice yields of various quality California rice

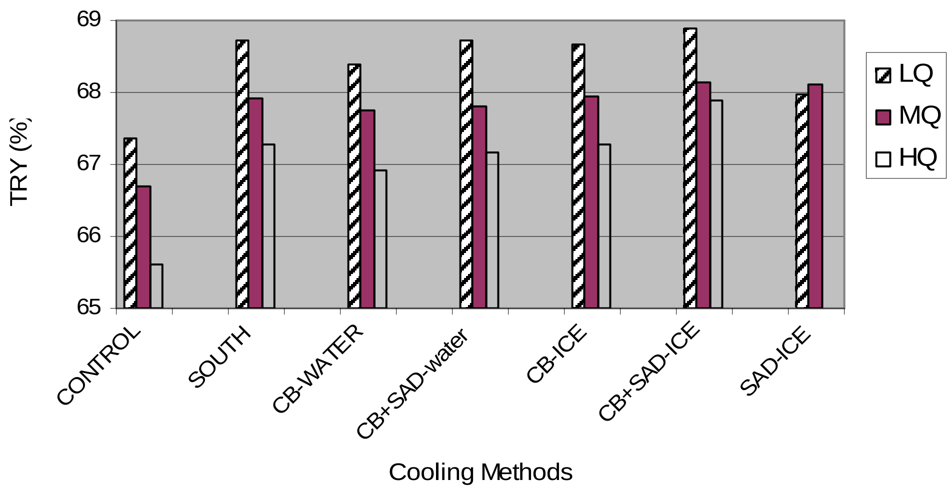


Fig. 4 Effect of cooling methods and milling procedures on TRYs of California rice

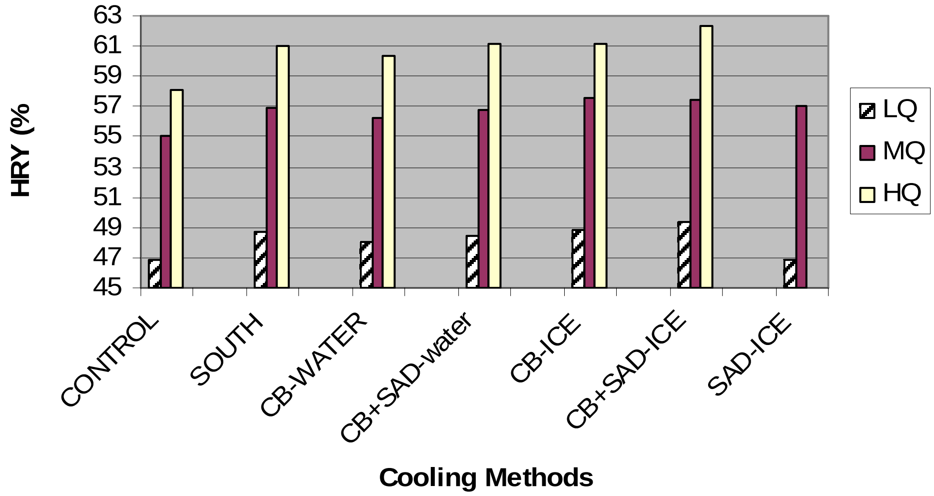
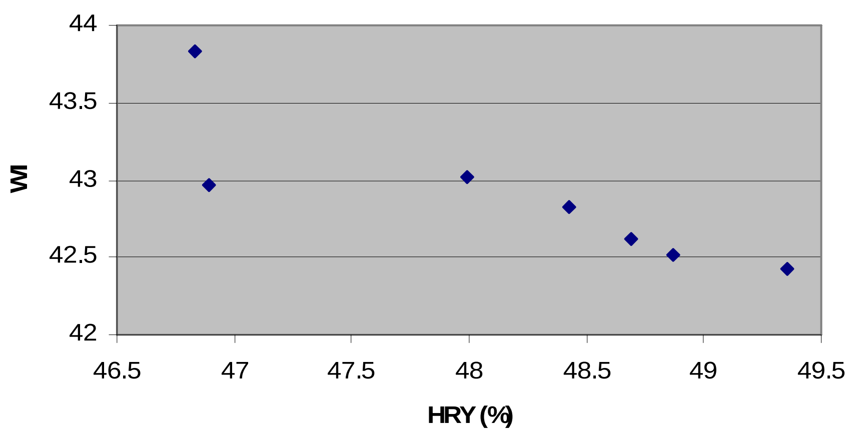


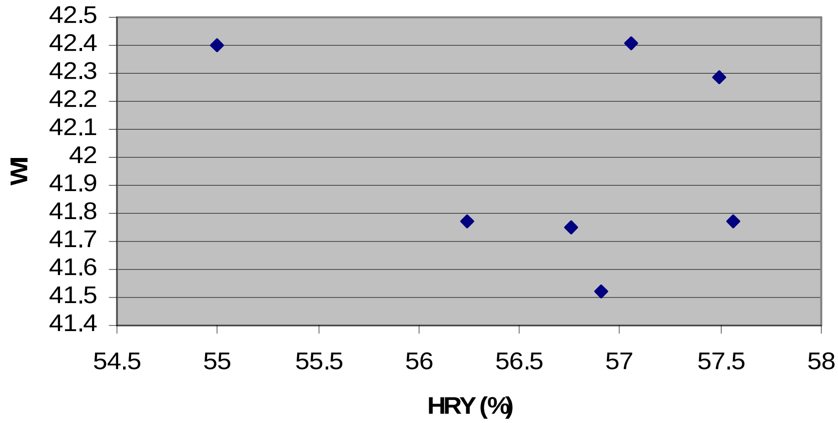
Fig. 5 Effect of cooling methods and milling procedures on HRYs of California rice

When the Western (CONTROL) and Southern (SOUTH) milling procedures are compared, the results clearly showed that the Southern standard milling procedures had higher TRYs and HRYs as we have observed before. The Southern milling procedures resulted in about 2-3% more HRY than the Western milling procedures. If the cutter bar with ice water or cutter bar plus saddle with room water were used, the obtained TRYs and HRYs were similar to those from the Southern milling procedures.

In general, the whiteness of milled rice was related to the HRYs and cooling conditions (Figs. 6a, 6b and 6c). The whiteness index (WI) decreased with the increased of HRYs for the low quality rice milled with various cooling conditions. However, for the rice of medium and high quality, some rice samples had high HRYs and WIs when the cooling was used. The exact reasons for resulting in such phenomena were not known. It could be useful information for further improving the current sample and commercial milling technologies if the mechanism is determined. More research work is needed in this area.



(a)



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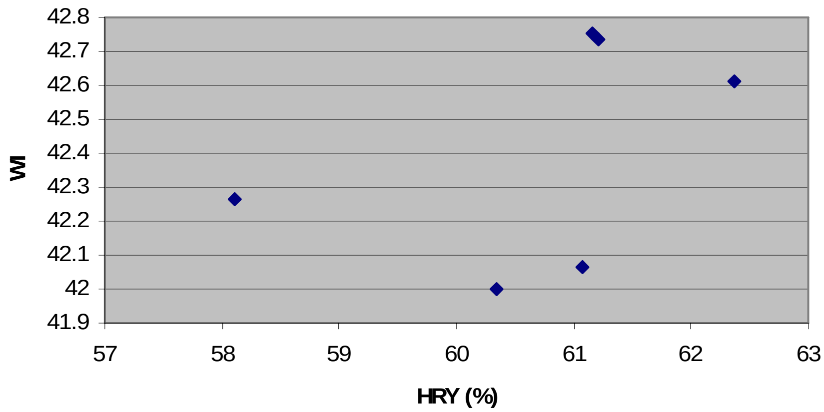


(c)

Fig. 6 Relationships between HRY and WI of rice milled with various cooling methods and procedures (a – low quality; b – medium quality; c – high quality)

The rice milled with the Southern procedures was darker than the rice milled with the Western procedures. However, the color requirement of milled rice was not specified in the FGIS procedures.

The quantitative quality data of milled rice under selected cooling conditions and milling procedures are summarized in Table 2. The HRYs from the Southern procedures were 1.9%, 1.9% and 3.0% higher for low, medium and high quality rice compared to that from the Western procedures. When combination of cutter bar and saddle heat exchangers with water at ambient temperature was used for cooling, the HRYs were very close to those obtained with the Southern procedures. The maximum difference was less than 0.3% for different quality rice. If the cooling combination with ice water was used, the HRYs were 0.7%, 0.6% and 1.3% higher than that the HRYs obtained with the Southern procedures for the rice of low, medium and high quality, respectively.

Table 2. Summarized milling results with selected milling conditions

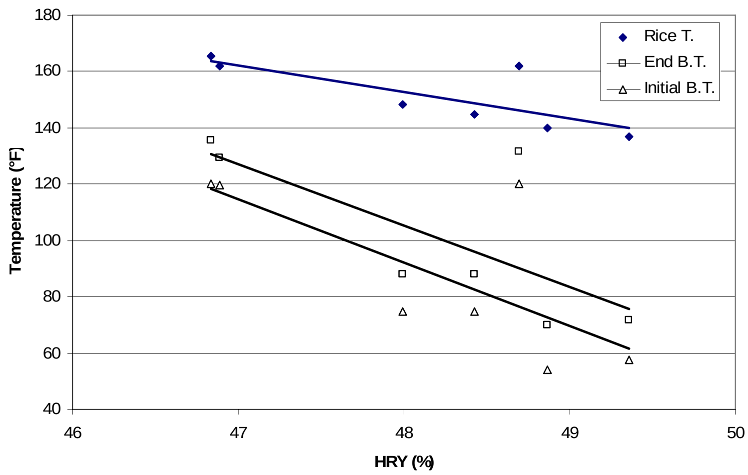
	Control		South		CB-SAD-Water		CB-SAD-Ice	
	HRY	WI	HRY	WI	HRY	WI	HRY	WI
Low	46.8	43.8	48.7	42.6	48.4	42.8	49.4	42.4
Med	55.0	42.2	56.9	41.5	56.8	41.8	57.5	42.3
High	58.1	42.3	61.1	42.1	61.2	42.7	62.4	42.6
Average	53.3	42.8	55.6	42.1	55.5	42.4	56.4	42.4

On average, the HRY obtained with the Western procedures was 2.3% higher than that obtained with the Southern procedures, which was consistent with the results we obtained in the past two years. Meanwhile, we noticed that the milled rice from the Southern procedures was darker (WI was 0.7 lower) than the rice milled with Western procedures. If the rice was milled to the similar whiteness with the two different procedures, the HRYs could be close. As mentioned previously, the standard rice sample milling procedures of the FGIS do not have any specific requirement for the whiteness of the milled rice.

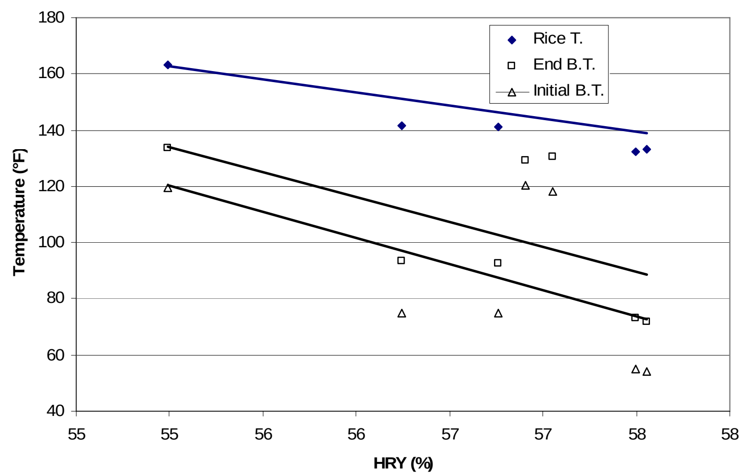
When cooling with saddle and cutter bar heat exchangers was used in the tests, the HRYs were improved. When water of ambient temperature was used as cooling medium, the HRYs obtained with Western procedures were virtually the same as those obtained with Southern procedures. But the whiteness was improved when the cooling was used. Similar whiteness was also obtained when ice water was used as the cooling medium. The ice water cooling further improved the HRY by 0.9% compared with that using water of ambient temperature. It is also important to mention that the cooling methods could lower the initial cutter bar temperature to the desired level very quickly with a high accuracy compared to current air cooling which is very difficult to control.

Temperatures and HRYs

The relationships between the HRYs and temperatures of milled rice, ending cutter bar and initial cutter bar were examined and shown in Figs. 7a, 76, and 7c for different quality rice. In general, there was a relationship between the HRY and temperature. A high initial cutter bar temperature corresponded to a high ending bar temperature and milled rice temperature, but low HRY. The results also verified our initial hypothesis that the milling temperature in the current rice sample milling was a critical factor affecting the rice quality appraisal results.



(a)



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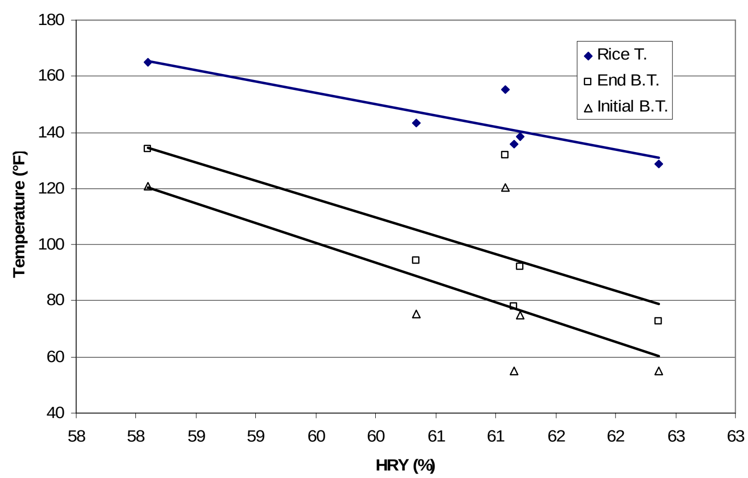

(c)

Fig.7 Relationships between HRYs and temperatures of milled rice, initial and ending cutter bar: (a) low quality rice; (b) medium quality rice; (c) high quality rice.

Quality Results of Southern Medium Rice

When the Southern medium rice was milled using both the Western and Southern procedures, the HRY obtained with the Southern procedures was 2.4% higher than that obtained with the Western procedures. This result is similar to the results obtained with the California medium grain rice (Table 3). The rice milled with the Southern procedures was also much darker than the rice milled with the Western procedures. Since the Southern procedures used lower weight for milling and polishing, the temperatures of milled rice, ending cutter bar and initial cutter bar were also lower compared with the Western procedures. This result was expected. Therefore, it is reasonable to believe that both rice from Southern region and California have similar milling characteristics. The same milling procedure from the FGIS may be used for both rice in the southern region and California.

Table 3 Milling results of southern medium grain rice

Milling Methods	TRY	HRY	WI	Rice T.	End B.T.	Initial B.T.
California	68.7	59.2	45.7	166	136	120
Southern	69.7	61.6	44.0	161	129	120

Recommendations for modifying the current rice sample milling procedures to improve the consistency and accuracy of milling sample appraisal results

Through the research during the past three years, our results clearly showed that the current Western standard rice sample milling procedure of FGIS resulted in significantly higher milling temperature compared with the current commercial milling practices, which resulted in significantly lower HRY in the quality appraisal. Meanwhile, the Western milling procedures were different from the Southern milling procedures that used lower milling and polishing weights (pressures). The high milling and polishing weights also contributed to the lower HRY compared with the Southern procedures. The current Western milling procedures including milling equipment need to be improved to match the advancement of the commercial milling technology. It is believed that there is a need to modify the current Western milling procedures to make the quality appraisal results in California match the results of commercial milling and the Southern milling procedures with high consistency and accuracy. Based on the research results, the following three different options may be considered for improving the milling consistency and accuracy of rice sample milling in California.

1. Adopt the Southern milling procedures in California to replace the current Western milling procedures that use high milling and polishing weights.
2. Employ cooling by means of combined internal and external exchangers that use water of ambient temperature as a cooling medium. Besides the improvement of quality appraisal results, this option is also expected to considerably increase the processing efficiency by reducing the cooling time since the cutter bar can cooled quickly to an ambient temperature. It is also easy to achieve an accurate initial cutter bar temperature resulting

in consistent milling results. The milling results with such cooling method should be similar to the results obtained with the Southern procedures even when high milling and polishing weights are used.

3. Employ cooling by means of combined internal and external heat exchangers that ice water as cooling medium. This option could also improve the milling quality and shorten cooling time. However, the drawback is that refrigeration equipment needs to be used for providing low temperature water.

Conclusions

The results from our research clearly showed that using both internal and external heat exchangers to cool the rice during milling was effective in reducing milling temperature and improving the TRY and HRY, as well as accurately reflecting the milling quality of rice samples. The developed internal heat exchanger could cool the cutter bar to a desired temperature in seconds compared to current air cooling which needs several minutes. The milling conditions were found to be very important factors affecting the rice quality appraisal results. The Western and Southern milling procedures produced significantly different quality appraisal results. The California and Southern medium grain rice had similar milling characteristics if the same milling procedure was used. Recommendations are made with regards to the adoption of Southern Milling Procedure in California or use of cooling mechanisms during milling to improve the quality appraisal results and the process efficiency.

PUBLICATIONS OR REPORTS

N/A

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

It has been found that the milled rice had very high temperature when the current FGIS 's rice sample milling procedures were used in California. Since the commercial rice milling industry has been updating its milling technology and equipment, it is believed that the milling temperature of commercial rice mill could be significantly lower than that of the lab mill used for the rice quality appraisal. Also, there are two different rice sample milling standards in the United States. Therefore, to assess the impact of the current milling standard on the quality appraisal result, it is important to develop efficient cooling devices for rice sample mill and determine the effect of milling conditions on the quality of milled rice, as well as to compare the Southern and Western standard procedures using rice from California and the southern region. The main objectives of the research were to determine the effects of different milling procedures and cooling methods on rice quality appraisal results using medium grain rice from California and the southern region and develop recommendations for modifying the current rice sample milling procedures.

In this research, medium grain rice samples from California and the Southern region were milled using the Western and Southern rice sample milling procedures. The Californian rice also milled using the Western milling procedures with various cooling methods. The cooling methods included using internal and external heat exchangers with water as cooling media at ambient (68-70°F) and low temperature (ice water, 34-38°F).

The research found that the temperatures of milled rice and ending cutter bar were increased with the increase of initial cutter bar temperature, which resulted in low total rice yield (TRY) and head rice yield (HRY). The developed cooling methods could significantly improve the TRY and HRY with reduced cooling time between two milling runs. The milling tests with cooling increased the HRYs from 1.2 to 4.3%. The HRYs of high quality rice, medium and low quality rice were improved by 1.2-2.6%, 1.2-2.6%, and 2.2-4.3%, respectively. The combination of Sad and CB heat exchangers with ice water had the highest TRY and HRY. The HRYs from the Southern procedures were 2.1%, 1.9% and 3.0% higher for low, medium and high quality rice compared to that from the Western procedures. When combination of cutter bar and saddle heat exchangers with water at ambient temperature was used for cooling, the HRYs were very close to that obtained with the Southern procedures. The maximum difference was less than 0.3% for different quality rice. If the cooling combination with ice water was used, the HRYs were 0.7%, 0.6% and 1.3% higher than that obtained with the Southern procedures for low, medium and high quality rice, respectively.

When the Southern medium rice was milled using both the Western and Southern procedures, the HRY obtained with the Southern procedures was 2.4% higher than that obtained with the Western procedures, which was similar to the results obtained with the California medium grain rice. Therefore, it is reasonable to believe that both rice from Southern and California had similar milling characteristics. A same milling procedure from the FGIS may be used for both rice in the Southern region and California.

Based on the research results, the following three different options may be considered for improving the milling consistency and accuracy of rice sample milling in California.

1. Adopt the Southern milling procedures in California to replace the current Western milling procedures that use high milling and polishing weights.
2. Employ cooling by means of combined internal and external exchangers that use water of ambient temperature as a cooling medium. Besides the improvement of quality appraisal results, this option is also expected to considerably increase the processing efficiency by reducing the cooling time since the cutter bar can cooled quickly to an ambient temperature. It is also easy to achieve an accurate initial cutter bar temperature resulting in consistent milling results. The milling results with such cooling method should be similar to the results obtained with the Southern procedures even when high milling and polishing weights are used.
3. Employ cooling by means of combined internal and external heat exchangers that ice water as cooling medium. This option could also improve the milling quality and shorten cooling time. However, the drawback is that refrigeration equipment needs to be used for providing low temperature water.

Acknowledgement

The investigators would like to express their appreciation for the great support received from the following personnel at UC Davis, CDFA and FGIS for the project.

Sanath Amaratunga
Chuck Britton
Homer Formentera
Mike Gabel
Michael Johnson
Sandra Newell
Dale Rice
Yi Zhu