بسم الله الرحمن الرحيم

Gezira State

Ministry of Agriculture, Animal Wealth and Natural Resources

GENERAL ADMINISTRATION OF AGRICULTURE

Rice Promotion Unit

In Collaboration with

Japan International Cooperation Agency (JICA)

&

Post-harvest Technology Expert

Mr. Tokumoto Osamu

Rice Post-harvest Technology Training Program

Rice Quality

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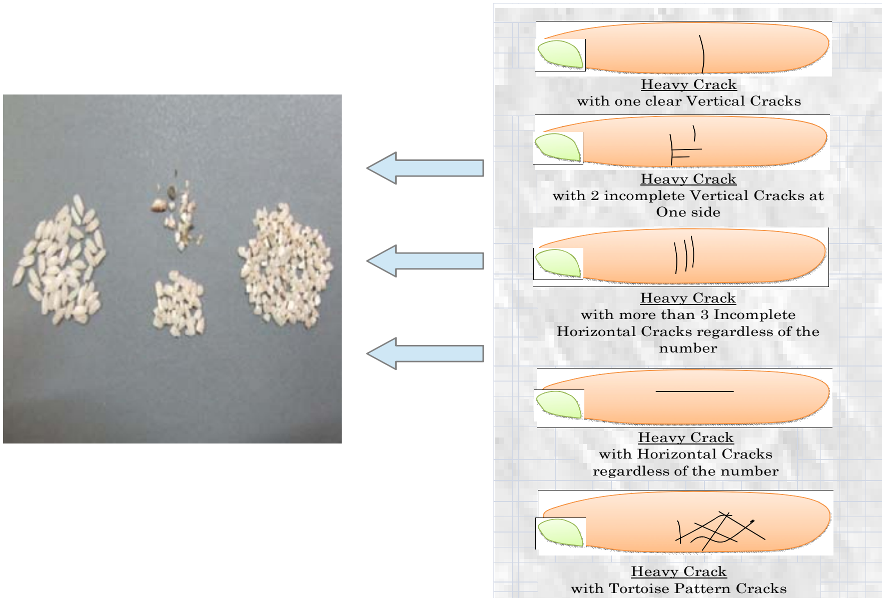
Introduction:

In the last year we worked with Mr. TOKUMOTO Osamu, the expert dispatched by JICA in Harvesting and Post-harvest Technology. The main issue at that time was cracks occurrence on rice kernels due to observation tour in Gezira and White Nile States by the expert. He stated that there are many cracks in paddy kernel, i.e., in brown rice, caused by late harvesting and low humidity at harvest time for equilibrium moisture content of rice kernel. These are increased post-harvest losses.

Types of cracks on brown rice



The expert recommended that we have to harvest rice at 18 – 24% Moisture Content to avoid fissuring and use parboiling equipment to treat cracked kernels. So, this year we focused on timely harvesting or adequate time for rice harvesting.

Rice Quality- an overview:

Generally we can define quality as the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs. This skills section examines the different factors that affect grain quality, and explains how to measure grain quality characteristics for both paddy and milled rice.

Quality of rice is not always easy to define as it depends on the consumer and the intended end use for the grain. All consumers want the best quality that they can afford. As countries reach self-sufficiency in rice production, the demand by the consumer for better quality rice has increased. Traditionally, plant breeders concentrated on breeding for high yields and pest resistance. Recently the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice. Grain quality is not just dependent on the variety of rice, but quality also depends on the crop production environment, harvesting, processing and milling systems.

The quality characteristics of paddy and milled rice can be considered separately.

In this year we used to determine the optimum time for harvesting by studying three physical characteristics and these are moisture content, hardness and cracked kernels ratio. We used these tools moisture meter, hardness meter and crack inspector, respectively. Data collection will be continued this season and next one.

We must put into consideration that there are other physical properties for paddy and both physical and chemical properties for milled rice. These properties are playing an important role in rice quality, marketing and exporting.

Seed Inspection

M.C Measuring

Threshing

Moisture Meter

Crack Detector

Hardness Meter

Quality characteristics of paddy:

A number of interrelated features determine the quality of paddy. These are:

- Moisture content of paddy,
- Purity degree,
- Varietal purity,
- Cracked grains,
- Immature grains,
- Discolored/fermented grains and damaged grains.

These characteristics are determined by the environmental weather conditions during production, crop production practices, soil conditions, harvesting, and post harvest practices.

Moisture content:

Moisture content has a marked influence on all aspects of paddy and rice quality and it is essential that paddy be milled at the proper moisture content to obtain the highest head rice yield.

Paddy is at its optimum milling potential at moisture content of 14% wet weight basis. Grains with high moisture content are too soft to withstand hulling pressure which results in grain breakage and possibly pulverization of the grain. Grain that is too dry becomes brittle and has greater breakage. Moisture content and temperature during the drying process is also critical as it determines whether small fissures and/or full cracks are introduced into the grain structure.

Degree of purity:

Purity is related to the presence of dockage in the grain. Dockage refers to material other than paddy and includes chaff, stones, weed seeds, soil, rice straw, stalks, etc. These impurities generally come from the field or from the drying floor. Unclean paddy increases the time taken to clean and process the grain. Foreign matter in the grain reduces milling recoveries and the quality of rice and increases the wear and tear on milling machinery.

Varietal Purity:

A mixture of varieties causes difficulties at milling and usually results in reduced capacity, excessive breakage, lower milled rice recovery and reduced head rice. Different sizes and shaped grains make it more difficult to adjust hullers, whiteners and polishers to produce whole grains. This results in low initial husking efficiencies, a higher percentage of re-circulated paddy, non-uniform whitening, and lower grade of milled rice.

Grain dimensions:

Grain size and shape (length-width ratio) is a varietal property. Long slender grains normally have greater breakage than short, bold grains and consequently have a lower milled rice recovery. The grain dimensions also dictate to some degree the type of milling equipment needed. For instance, the Japanese designed milling equipment may be better suited to short bold japonica grains whereas Thai made equipment will be more suitable for longer, slender grain types.

Cracked grains:

Overexposure of mature paddy to fluctuating temperature and moisture conditions leads to development of fissures and cracks in individual kernel. Cracks in the kernel are the most important factor contributing to rice breakage during milling. This results in reduces milled rice recovery and head rice yields.

Immature grains:

The amount of immature paddy grains in a sample has a major affect on head rice yield and quality. The immature rice kernels are very slender and chalky and this results in excessive production of bran, broken grains and brewer's rice. The optimal stage to harvest grain in many countries is at about 20-24% grain moisture or about 30 days after flowering. If the harvest is too late, many grains are lost through shattering or dry out and are cracked during threshing, which causes grain breakage during milling.

Damaged grains:

Paddy deteriorates through biochemical change in the grain, the development of off-odors and changes in physical appearance. These types of damage are caused from water, insects, and heat exposure.

Yellowing:

Yellowing is caused by over-exposure of paddy to wet environmental conditions before it is dried. This results in a combination of microbiological and chemical activity that overheats the grain. These fermented grains frequently possess partly gelatinized starch cells and generally resist the pressures applied during grain milling. While the presence of fermented grain does not affect milling yields it does downgrade the quality of the milled rice because of the unattractive appearance. Insect- or mold-damaged grains can be distinguished by the presence of black spots around the germ end of the brown rice kernel which are caused by the microorganisms, insects, or a combination. Mold damage in particular is increased by unfavorable weather conditions. In the process of milling, these black spots are only partly removed which consequently increases the presence of damaged grains.

Quality characteristics of milled rice:

The quality characteristics of milled rice are classified both physically, and chemically.

Review the following terms before reading about physical and chemical characteristics of milled rice:

• Paddy or rough rice = similar term for paddy, or rice retaining its husk after threshing.

• Brown rice or husked rice = paddy from which the husk has been removed.

• Milled rice = rice after milling which includes removing all or part of the bran and germ from the husked rice.

• Head rice = milled rice with length greater or equal to three quarters of the average length of the whole kernel

• Large broken = milled rice with length less than three quarters but more than one quarter of the average length of the whole kernel.
• Small broken or "brewers rice" = milled rice with length less than one quarter of the average length of the whole kernel.
• Whole kernel = milled rice grain without any broken parts.
• Milling recovery = percentage of milled rice (including broken) obtained from a sample of paddy.
• Head rice recovery = percentage of head rice (excluding broken) obtained from a sample of paddy.

Physical characteristics:

Milling degree:

The degree of milling is a measure of the percent bran removed from the brown rice kernel. Milling degree affects milling recovery and influences consumer acceptance. Apart from the amount of white rice recovered, milling degree influences the color and also the cooking behavior of rice. Unmilled brown rice absorbs water poorly and does not cook as quickly as milled rice. The water absorption rate improves progressively up to about 25% milling degree after which, there is very little effect.

Head rice:

“Head rice” or head rice percentage is the weight of head grain or whole kernels in the rice lot. Head rice normally includes broken kernels that are 75-80% of the whole kernel. High head rice yield is one of the most important criteria for measuring milled rice quality. Broken grain has normally only half of the value of head rice. The actual head rice percentage in a sample of milled rice will depend on both varietal characteristics (i.e. the potential head rice yield), production factors, and harvesting, drying and milling process. In general harvesting, drying, and milling can be responsible for some losses and damage to the grain.

Whiteness:

Whiteness is a combination of varietal physical characteristics and the degree of milling. In milling, the whitening and polishing greatly affect the whiteness of the grain. During whitening, the silver skin and the bran layer of the brown rice is removed. Polishing after whitening is carried out to improve the appearance of the white rice. During polishing some of the bran particles stick to the surface of the rice which polishes and gives a shinier appearance.

Chalkiness:

If part of the milled rice kernel is opaque rather than translucent, it is often characterized as “chalky”. Chalkiness disappears upon cooking and has no effect on taste or aroma, however it downgrades milled rice. Excessive chalkiness is caused by interruption during the final stages of grain filling. Though chalkiness disappears upon cooking and has no direct effect on cooking and eating qualities, excessive chalkiness downgrades the quality and reduces milling recovery.

Chemical characteristics:

Gelatinization temperature:

The time required for cooking milled rice is determined by gelatinization temperature or GT. Environmental conditions, such as temperature during ripening, influence GT. A high ambient temperature during development results in starch with a higher GT. GT of milled rice is evaluate by determining the Alkali spreading value. In many rice-growing countries, there is a distinct preference for rice with intermediate gelatinization temperature.

Amylose content:

Starch makes up about 90% of the dry matter content of milled rice. Starch is a polymer of glucose and amylose is a linear polymer of glucose. The amylose content of starches usually ranges from 15 to 35%. High amylose content rice shows high volume expansion (not necessarily elongation) and high degree of flakiness.

High amylose grains cook dry, are less tender, and become hard upon cooling. In contrast, low-amylose rice cooks moist and sticky. Intermediate amylose rice are preferred in most rice-growing areas of the world, except where low-amylose japonicas are grown.
Based on amylose content, milled rice is classified in “amylose groups”, as follows:

- waxy (1-2% amylose),
- very low amylose content (2-9% amylose),
- low amylose content (10-20% amylose),
- intermediate amylose content (20-25% amylose) and
- high amylose content (25-33% amylose).

Amylose content of milled rice is determined by using the colorimetric iodine assay index method.

Gel consistency:

Gel consistency measures the tendency of the cooked rice to harden after cooling. Within the same amylose group, varieties with a softer gel consistency are preferred, and the cooked rice has a higher degree of tenderness. Harder gel consistency is associated with harder cooked rice and this feature is particularly evident in high-amylose rice. Hard cooked rice also tends to be less sticky. Gel consistency is determined by heating a small quantity of rice in a dilute alkali.

Procedures for Measuring quality of paddy grain:

Crack Detector:

Using the Paddy Crack Detector, count the number of cracked grains in a 100 grain sample then compute the % cracked grains using the equation:

$$\% \text{ Cracked grains} = \frac{\text{Number of cracked grains}}{\text{100 grains}} \times 100$$

Grain Dimensions:

Using a caliper or photographic enlarger, collect 20 paddy samples at random from each replicate and measure the dimensions to obtain the average length and width of the paddy grains. To obtain the paddy shape, the following equation can be used:

$$\text{Length to width ratio (L/W)} = \frac{\text{Average paddy length, mm}}{\text{Average paddy width, mm}}$$

Immature Grains:

Select a 25 gm grain sample and select, segregate and weigh the immature grains in sample. Calculate the percentage immature grains in the sample using the formula:

$$\text{\% Immature grains} = \frac{\text{Wt. of immature grains}}{\text{Total weight of samples}} \times 100$$

Dockage in Paddy:

Remove light foreign matter, stones, weed and seeds from a 100gm sample. Obtain the total weight then compute the dockage percentage as follows:

$$\text{\% Dockage} = \frac{\text{Wt. of dockage}}{\text{Total wt. of sample}} \times 100$$

1000 Kernel Weight:

Determined by counting and weigh 1,000 grains (paddy).

Procedures for Measuring quality of milled rice:

Milling degree:

Milling degree is computed based on the amount of bran removed from the brown rice. To obtain the weight of brown rice, dehull the paddy samples using the Laboratory Huller. Estimate the percent milling degree using the following equation:

$$\% \text{ Milling degree} = \frac{\text{Wt of milled rice}}{\text{Wt of brown rice}} \times 100$$

Milling recovery:

Using the Abrasive Whitener, mill the dehulled samples. Compute milling recovery by dividing the weight of milled rice recovered by the weight of the paddy sample, as follows:

$$\% \text{ Milling recovery} = \frac{\text{Wt of milled rice}}{\text{Wt of sample used}} \times 100$$

Dockage in Milled Rice:

Select, segregate and weigh the foreign matter. Record the number of unhulled grains collected from the sample. Determine the percentage of dockage of milled rice using the equation:

$$\% \text{ Dockage (mr)} = \frac{\text{Wt. of dockage}}{\text{Total wt. of milled rice}} \times 100$$

Broken grain:

Using the Grain Grader, separate the broken grain from the whole grains. Compute the percentage of the head rice and broken using the following equations:

$$\% \text{ Head rice} = \frac{\text{Wt of whole grains}}{\text{Wt of paddy samples}} \times 100$$

$$\% \text{ Brokens} = \frac{\text{Wt of broken grains}}{\text{Wt of paddy samples}} \times 100$$

Chalkiness:

A visual rating of the chalky proportion of the grain is used to measure chalkiness based on the standard Evaluation System SES scale presented below:

Scale	% area of chalkiness
1	less than 10
5	10-20
9	more than 20

Select, segregate and weigh the chalky grains (SES Scale 9). Determine the % chalky grain using the equation:

$$\%\ Chalky\ grain = \frac{Wt\ of\ chalky\ grains}{Wt\ of\ milled\ rice} \times 100$$

Whiteness:

Measure the grain whiteness using the Whiteness Meter. Separate and weigh yellow-fermented grains. Calculate the percentage of yellow/fermented grains using the formula:

$$\%\ Yellow\ grains = \frac{Wt.\ yellow\ grains}{Total\ wt.\ of\ milled\ rice} \times 100$$

Grain Shape:

Follow the procedure of determining grain shape of paddy. Based on the length to width ratio, the shape of the milled rice will be determined. L/W ration is given by:

$$L/W\ ratio = \frac{Average\ length\ of\ rice,\ mm}{Average\ width\ of\ rice,\ mm}$$

The ISO Classification is as follows:

Scale	Shape	L/W ratio
1	Slender	Over 3.0
3	Medium	2.1 – 3.0
5	Bold	1.1 – 2.0
9	Round	1.0 or less

1000 grain weight:

Count and weigh 1,000 whole grains.

Amylose content:

Select twenty grains and ground them in a Cyclone Mill. Amylose content is analyzed using the simplified iodine colorimetric procedure. Samples are categorized into low, intermediate and high based on the following grouping:

Category	**%Amylose Content**
Waxy	1-2
Very low amylose	2-9
Low	10-20
Intermediate	20-25
High	25-30

Gelatinization temperature (GT):

GT is measured by determining the alkali-spreading value for which the alkali digestibility test is employed. Grains are soaked in 1.7% KOH and incubated in a 30°C oven for 23 hours. Measurement ranges are based on the following: Gelatinization temperature is estimated by the extent of alkali spreading and clearing of milled rice soaked in 1.7% KOH at room temperature or at 39^0C for 23 hours. The degree of spreading is measured using a seven-point scale as follows:

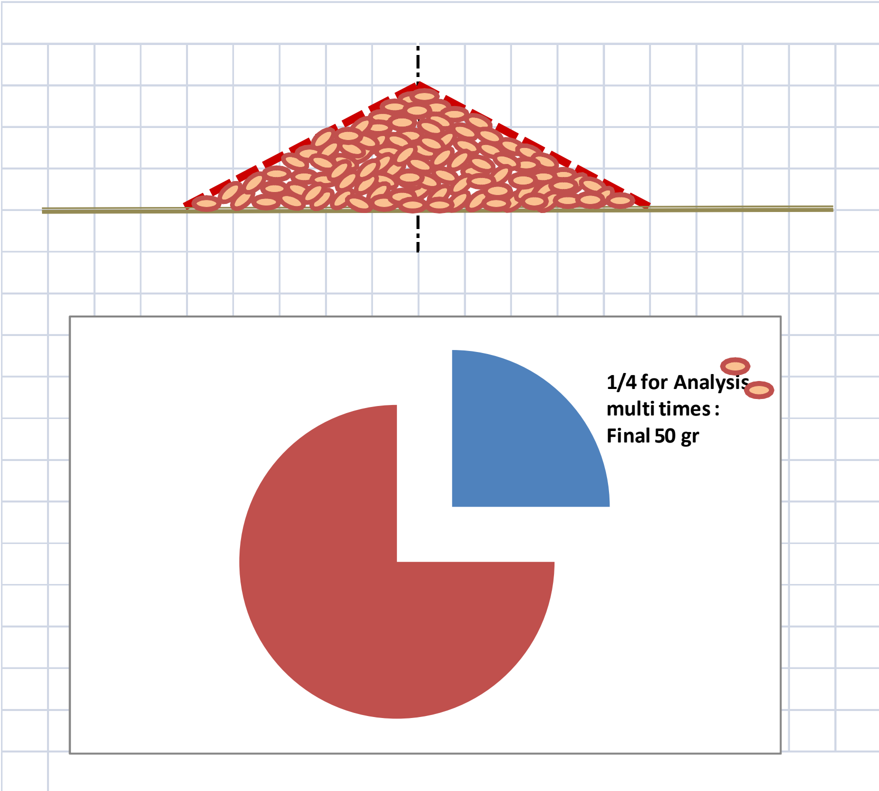
1. grain not affected
2. grain swollen,
3. grain swollen, collar incomplete and narrow,
4. grain swollen, collar complete and wide,
5. grain split or segmented, collar complete and wide,
6. grain dispersed, merging with collar; and
7. grain completely dispersed and intermingled.

Category	Temp ranges (°C)	Alkali Spreading Value
Low	55-69	6-7
Intermediate	70-74	4-5
High	75-79	2-3

Gel consistency:

Select from two to 10 grains and ground separately in the Wig-L Bug. Gel consistency is measured by the cold gel in a horizontally-held test tube, for one hour. Measurement ranges and category are as follows:

Category	Consistency, mm
Soft	61-100
Medium	41-60
Hard	26-40



Sample Dividing

Structure Analysis of Rice Quality

Production Location: Soureeba. Variety: Local Date: Oct. 17. 2012. No. 2012-01.

		Item	(gr)	(%)	Memo
Paddy Structure	Paddy Base	Paddy	46.42	93.19%	* 2011 Product (80 kg bag) * Cleaned paddy * Inspected by Omer
		Immatured Paddy	0.14	0.28%	
		Empty Paddy	0.08	0.16%	
		Paddy with Rachis	0.87	1.75%	
		Husked Kernel	0.01	0.02%	
		Impurities	0.12	0.24%	
		Sand & Small Stone	0.96	1.93%	
		Mud Ball	1.21	2.43%	
		Total	49.81		
		Moisture Contents	9.70%		

Structure Analysis of Rice Quality

Approximate 50 gr each

Production Location: Soureeba, Variety: Local, Date: Oct. 17, 2012, No. 2012-01,

Item				(gr)	(%)	Memo
Paddy Structure 籾組成	Paddy Base 籾ベース	籾	Paddy	46.42	93.19%	* 2011 Product (80 kg bag) * Cleaned paddy * Inspected by Omar
		未熟粒	Immatured Paddy	0.14	0.28%	
		空籾	Empty Paddy	0.08	0.16%	
		枝梗付籾	Paddy with Rachis	0.87	1.75%	
		脱稃粒	Husked Kernel	0.01	0.02%	
		夾雑物	Impurities	0.12	0.24%	
		砂・石	Sand & Small Stone	0.96	1.93%	
		粘土（マッド・ボール	Mud Ball	1.21	2.43%	
			Total	49.81		
		含水率	Moisture Contents	9.70%		
Cracked Kernels 胴割米	(Brown Rice Base) 玄米ベース	完全粒	Complete Kernel (Non-clacked kernel)			
		軽胴割米	Light Cracked Kernel			
		重胴割米	Heavy Cracked Kernel			
		砕米	Broken Rice			
			Total			
		含水率	Moisture Contents	–		
Milled Rice Quality 精米品質	(Milled Rice Base) 精米ベース	完全粒	Head Rice			
		大砕米	Large Broken			
		中砕米	Medium Broken			
		小砕米	Small Broken			
		極小砕米	Fine Broken			
		夾雑物	Impurities			
		糠	Bran			
			Total			
		含水率	Moisture Contents	–		

Note:

Water Falling Date: ____________ , ____ days before Harvest ____________

Harvest Date: ,

Threshing Date: ,

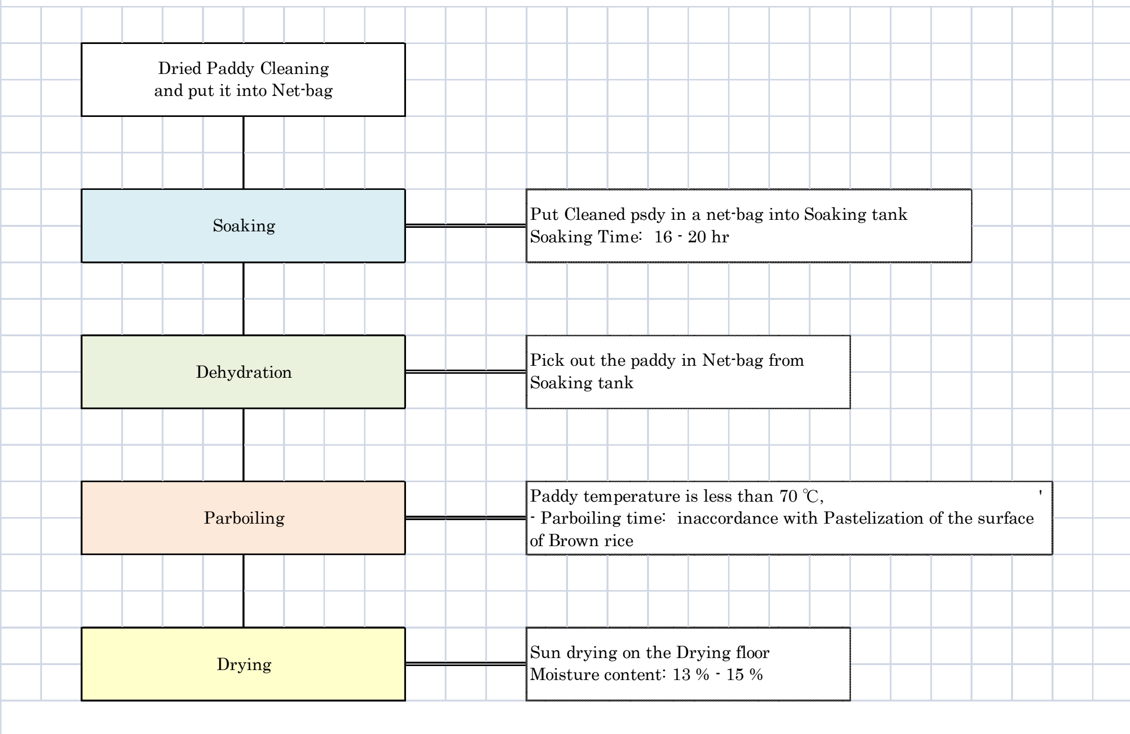
Drying Date:

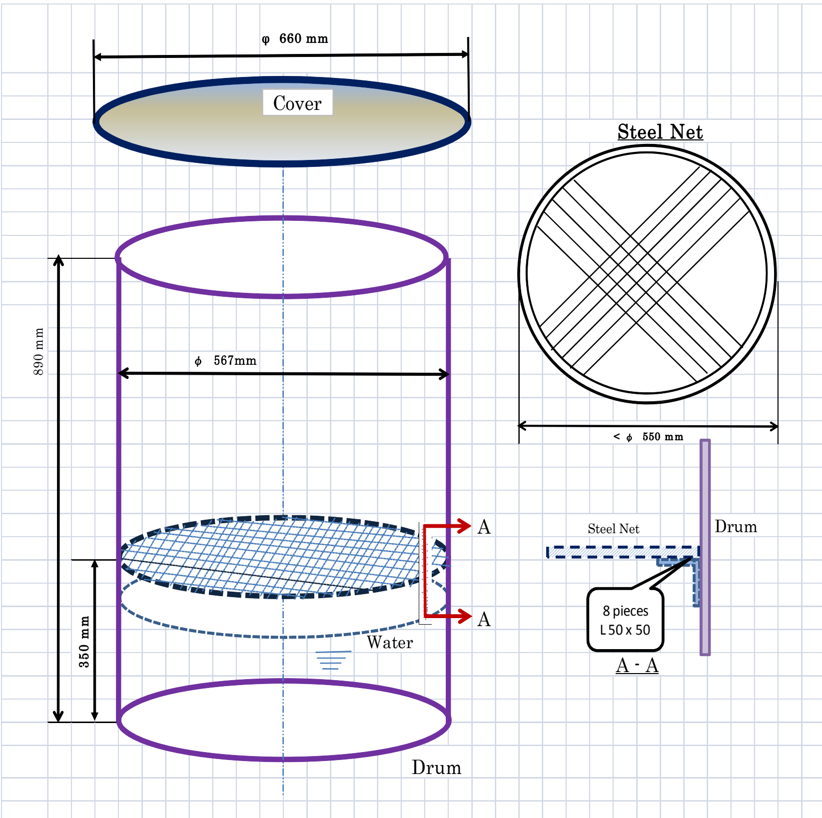
Cleaning Date:

Storage condition:

Prototype of Parboiling Equipment

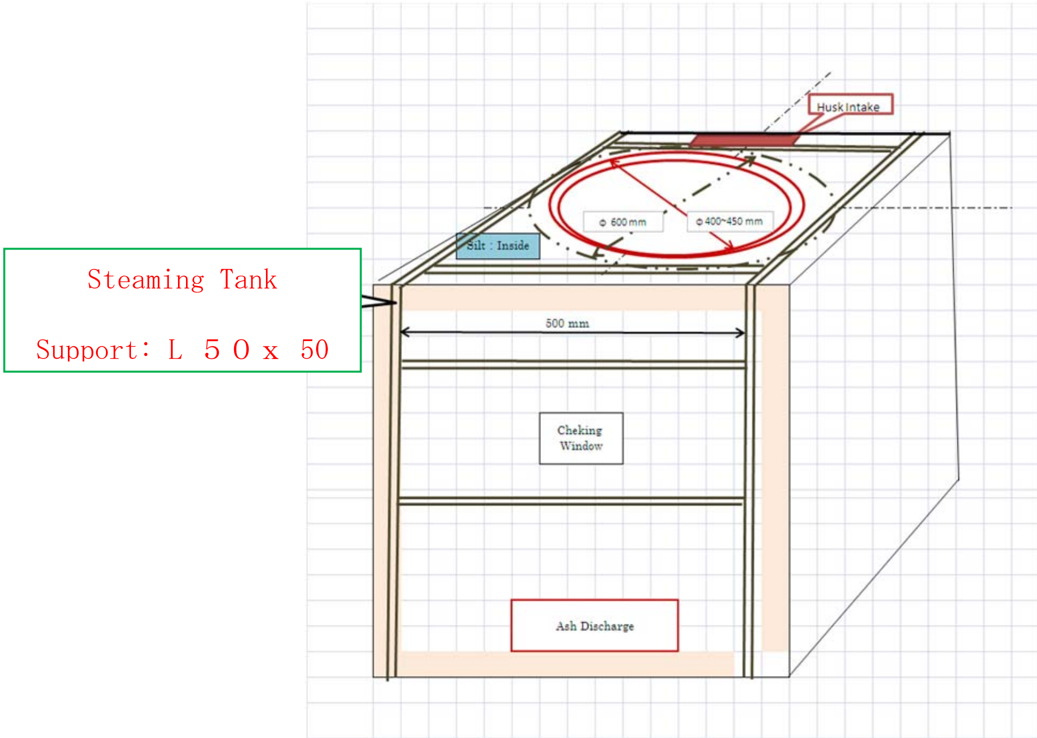
Testing Process of Parboiled Rice (Draft)

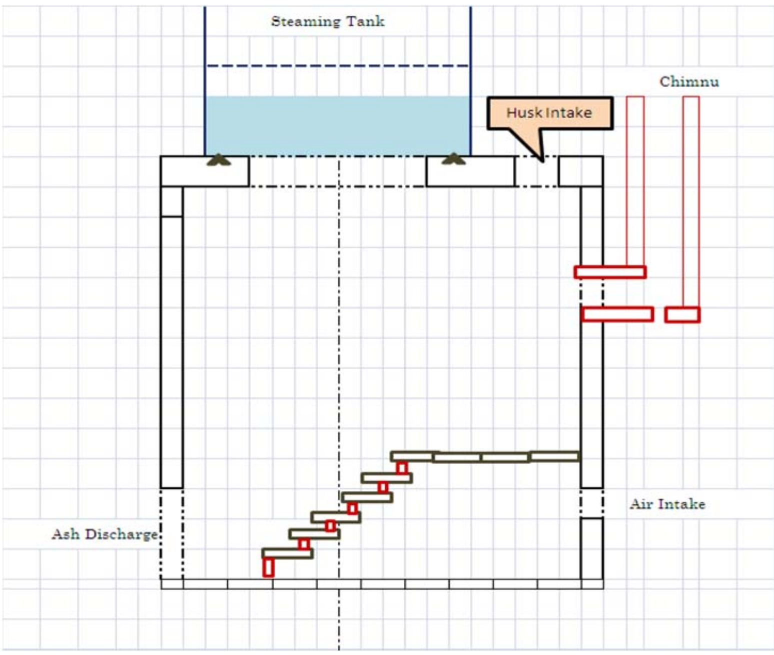




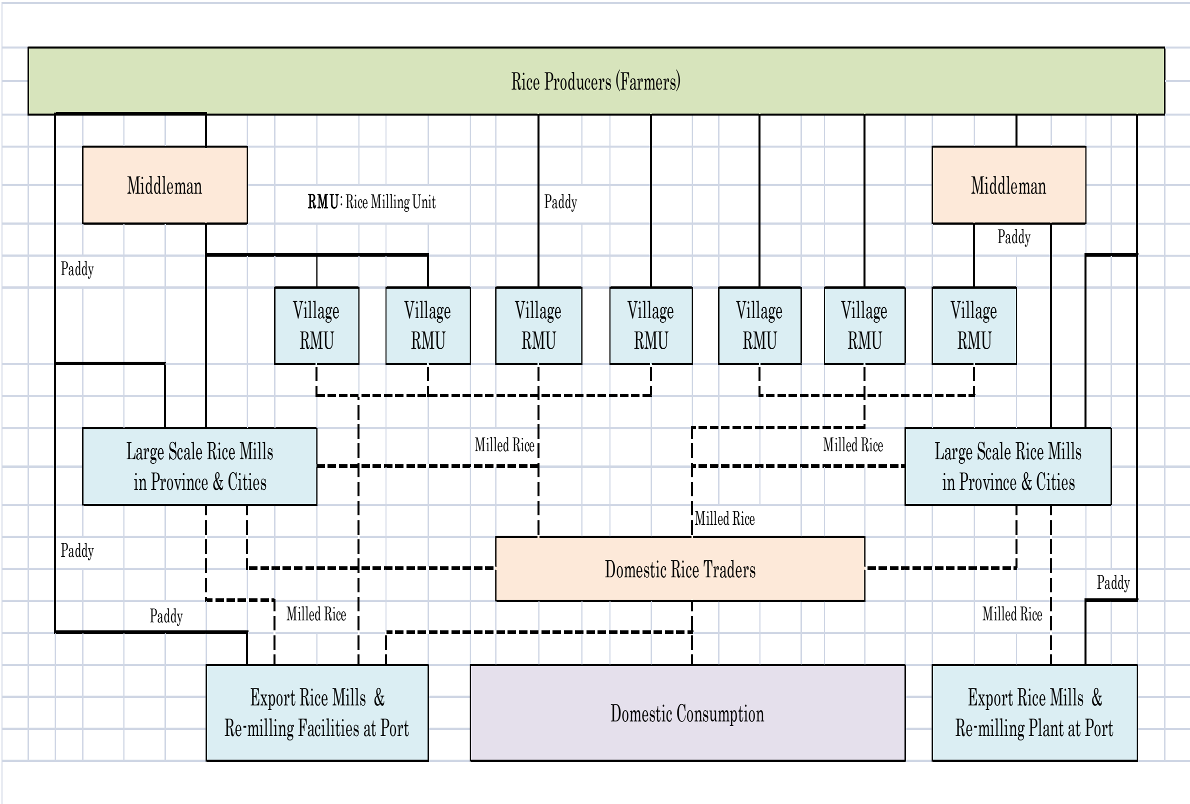
Parboiling Equipment

Outline of Furnace

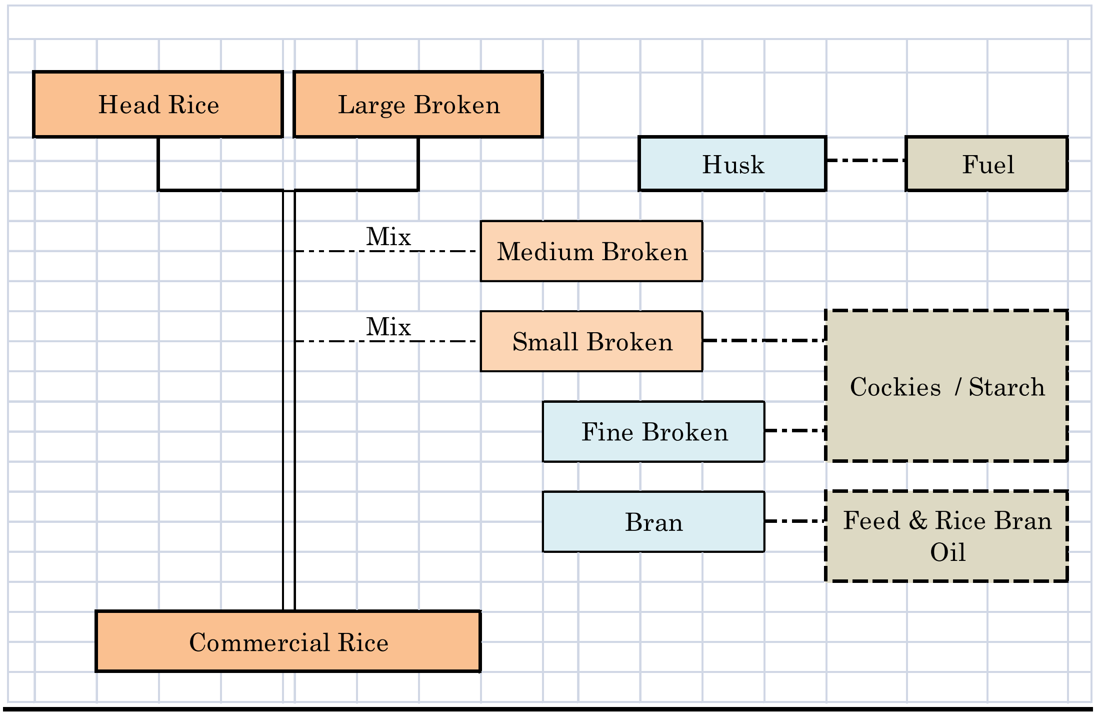




Future Rice Industry in Sudan



Utilization of Rice (Paddy)



DAVICONTROL

Inspection Department

Charactoristics of White Rice

TCVN - 5644 : 1999

	Grades	Grain Classification: Very long grain I > 7.0 mm	Grain Classification: Long grain I : 6.0 - 7.0 mm	Grain Classification: Short grain I < 6.0 mm	Whole grain (Head rice) %	Brokens: Size (mm)	Brokens: Brokens and small brokens (%)	Brokens: Small brokens %	Red kernel	Red streaked kernel & under milled kernel	Other kernels not exeeding: Yellow kernel	Chalky kernel	Damaged kernel	Waxy kernel	Immatured & malformed kernel	Impurities	Paddy (grain/kg)	Moisture	Milling degree
Long grain rice	100 % class A	≧ 10	—	≦ 10	> 60	(0.5 - 0.8) I	<4.0	≦ 0.1	0	0.25	0.2	5	0.25	1.5	0	0.05	10	14.0	Extra well milled
	100 % class B	≧ 10	—	≦ 10	≧ 60	(0.5 - 0.8) I	< 0.45	≦ 0.1	0	0.25	0.2	5	0.50	1.5	0	0.05	10	14.0	Extra well milled
	5%	≧ 5	—	≦ 15	≧ 60	(0.35 - 0.75) I	5.0 ± 2	≦ 0.2	2		0.5	6	1.0	1.5	0.2	0.1	15	14.0	Well milled
	10%	≧ 5	—	≦ 15	≧ 55	(0.35 - 0.65) I	10 ± 2	≦ 0.3	2		1.0	7	1.25	1.5	0.2	0.2	20	14.0	Well milled
	15%	—		< 30	≧ 50	(0.25 - 0.6) I	15 ± 2	≦ 0.5	5.00		1.25	7	1.50	2.0	0.3	0.2	25	14.0	Reasonable
	20%	—		< 50	≧ 45	(0.25 - 0.5) I	20 ± 2	≦ 1.0	7.00		1.25	7	1.50	2.0	0.5	0.3	25	14.5	Reasonable
	25%	—		< 50	≧ 40	(0.25 - 0.5) I	25 ± 2	≦ 2.0	7.00		1.50	8	2.00	2.0	1.5	0.5	30	14.5	Ordinary
	35%	—		< 50	≧ 32	(0.25 - 0.5) I	35 ± 2	≦ 2.0	7.00		2.0	10	2.00	2.0	2.0	0.5	30	14.5	Ordinary
	45%	—		< 50	≧ 28	(0.25 - 0.5) I	45 ± 2	≦ 3.0	2		2.0	10	2.50	2.0	2.0	0.5	30	14.5	Ordinary
Short grain rice	5%	—		> 75	≧ 60	(0.35 - 0.75) I	5.0 ± 2	≦ 0.2	2		0.5	6	1.0	1.5	0.2	0.1	15	14.0	Well milled
	10%	—		> 75	≧ 55	(0.35 - 0.7) I	10 ± 2	≦ 0.3	5.00		1.0	7	1.25	2.0	0.2	0.2	20	14.0	Well milled
	15%	—		> 70	≧ 50	(0.35 - 0.65) I	15 ± 2	≦ 0.5	5.00		1.25	7	1.50	2.0	0.3	0.2	25	14.0	Reasonable
	20%	—		> 70	≧ 45	(0.25 - 0.6) I	20 ± 2	≦ 1.0	7.00		1.25	7	1.50	2.0	0.5	0.3	25	14.5	Reasonable
	25%	—		> 70	≧ 40	(0.25 - 0.5) I	25 ± 2	≦ 2.0	7.00		1.50	8	2.00	2.0	1.5	0.5	30	14.5	Ordinary
	35%	—		> 70	≧ 32	(0.25 - 0.5) I	35 ± 2	≦ 2.0	7.00		2.0	10	2.00	2.0	2.0	0.5	30	14.5	Ordinary
	45%	—		> 70	≧ 28	(0.25 - 0.5) I	45 ± 2	≦ 3.0	7.00		2.0	10	2.50	2.0	2.0	0.5	30	14.5	Ordinary

Notice:

I : Average length of rice kernel