Impact of Production Factors on Milling Yield

Impacts of rice production and processing operations on milling and sensory quality; Current investigations

LATU, Montevideo, Uruguay

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Rice Processing Program Sponsors (International)

Europe

Switzerland

Buhler
Rice Processing Program Sponsors
(International)

South America

Uruguay

LATU
100 kg
Rough Rice

20 kg
Hulls

80 kg
Brown Rice

10 kg
Bran

70 kg
Milled Rice

10-15 kg
Brokens

55-60 kg
Head Rice

Measurement of Milling Yield

Hulling

Milling

Separation
Overview of production factors studied:

- Nighttime air temperatures during kernel development
- Nitrogen fertilizer application amounts
- Harvest moisture content
Overview of production factors studied:

- **Nighttime air temperatures during kernel development**
- Nitrogen fertilizer application amounts
- Harvest moisture content
Rice Kernel Developmental Stages

The Development of the Individual Rice Grain from Anthesis through Grain Dry-down

R4  R5  R6  R7  R8
Increasing nighttime air temperature, above critical levels, during kernel development:

1. Increases chalk
2. Reduces milling yields
3. Reduces amylose content
4. Increases paste viscosity
5. Increases total lipid content
6. Increases gelatinization temperature
Overview of production factors studied:

• Nighttime air temperatures during kernel development
• Nitrogen fertilizer application amounts
• Harvest moisture content
Individual kernel moisture meter

Shizuoka Seiki CTR 800E
Individual kernel moisture content distributions of rice panicles

[Graph showing the distribution of moisture content in rice panicles with a bulk average MC of 22.7% for Bengali rice.]

Bengal

Bulk average MC of 22.7%
Individual kernel moisture content distributions of rice panicles

Bengal

Bulk average MC of 14.3%
Optimal HMC from a Milling Yield Standpoint

- **Harvest early**: weak, immature kernels in the bulk that break during milling

- **Harvest late**: fissured kernels due to rapid moisture adsorption

Results in a parabolic HRY vs HMC relationship
Head Rice Yield vs. Harvest MC Curve

Drew (Keiser, AR)

Harvest moisture content, %w.b.

Head rice yield, %
Head Rice Yield vs. Harvest MC Curve

Drew (Keiser, AR)

Head rice yield, %

Harvest moisture content, %w.b.
**Head Rice Yield vs. Harvest MC Curve**

Drew (Keiser, AR)

- **Head rice yield, %**
- **Harvest moisture content, %w.b.**

![Immature kernels](image)
Head Rice Yield vs. Harvest MC Curve

Drew (Keiser, AR)

Head rice yield, %

Harvest moisture content, %w.b.
Fissuring due to rapid moisture adsorption
Mechanism of fissure formation

H₂O

Fissure initiates

Fissure
Head Rice Yield vs. initial MC prior to soaking

Initial moisture content (%) vs. Head rice yield (%)

- Cheniere
- CL 151
- CLXL 745
Fissured kernel percentage vs. harvest MC
Sample lot

- Individual kernel MC
- Fissure enumeration
- Head rice yield
Samples

- **Cultivars/Hybrids:** long-grains, medium-grains
- **Harvest MCs:** 26 – 12% @ approx. 2 pp increments
Cypress (Keiser, AR), 1999

Head rice yield, %

Fissured kernels, %

Harvest moisture content, %

1999
Drew (Keiser, AR)

2000

Harvest moisture content, %

Head rice yield, %
2000

Drew (Stuttgart, AR)

Head rice yield, %

Harvest moisture content, %

Graph showing the relationship between harvest moisture content and head rice yield for the year 2000 at Drew (Stuttgart, AR).
Determining the harvest MC to attain peak head rice yield

[Graph showing the relationship between harvest moisture content and head rice yield]
<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Cultivar</th>
<th>Opt. HMC</th>
<th>Opt. HMC Range</th>
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“Optimal” harvest MCs (for Arkansas conditions):

- Medium-grains: 22-24%
- Long-grains: 19-22%
Harvest Moisture Content (HMC) Effects on Drying Cost (typical example)

- < 13.5%
- 13.6 to 18.9%
- 19.0 to 21.9%
- > 22%
“Optimal” harvest MCs (for Arkansas conditions):

- Medium-grains: 22-24%
- Long-grains: 19-22%
Overview of production factors studied:

- Nighttime air temperatures during kernel development
- Nitrogen fertilizer application amounts
- Harvest moisture content
Nitrogen rate by harvest MC study:

• Stuttgart, Arkansas; 2011, 2012, and 2013
• Five N-rates: 0, 40, 80, 120, and 160 lb/ac
  • Single pre-flood application
• Three harvest MCs;
  – Low (14-16%)
  – Medium (18-20%)
  – High (22-24%)
• Three cultivars; Cheniere, Wells, and CL XL745
• Four replications
$N$-Rate × Harvest MC Head rice yield
N-Rate × Harvest MC Brown Rice Chalk

![Bar chart showing the effect of fertilizer-N application on brown rice chalky area.](chart)

- **(L) 14-16%**
- **(M) 18-20%**
- **(H) 22-24%**

**Y-axis**: Brown rice chalky area, %

**X-axis**: Fertilizer-N applied, lb/ac

0 40 80 120 160
N-Rate × Harvest MC **Head Rice Chalk**

![Graph showing the effect of fertilizer-N applied (lb/ac) on Head rice chalky area (%). The graph includes different levels of harvest moisture content (HC) and fertilizer-N application rates.]

- **(L) 14-16%**
- **(M) 18-20%**
- **(H) 22-24%**

**X-axis:** Fertilizer-N applied, lb/ac

**Y-axis:** Head rice chalky area, %
N-Rate × Harvest MC Crude Protein

[Bar chart showing the effect of different fertilizer-N applications (0, 40, 80, 120, 160 lb/ac) on crude protein levels at three harvest MC (L: 14-16%, M: 18-20%, H: 22-24%) conditions.]
Rice Processing Program

Introduction

The mission of the Rice Processing Program is to conduct both basic and applied research to improve the efficiency and effectiveness of current processing operations, as well as to provide fundamental information to be utilized in the development of new products and processes. The ultimate goal is to enhance the quality and value of rice and rice products. The research scope ranges from property characterization at harvest to assessment of consumer preferences of processed rice; emphasis areas include: pre-harvest property measurement, drying, storage, milling, quality assessment, and cereal chemistry of rice and rice products.

Program personnel represent engineering, cereal science, sensory evaluation, and plant physiology capabilities. The integrated nature of the rice industry’s research needs has necessitated our multidisciplinary, systematic approach to research.

http://uarpp.uark.edu
The Rice Processing Program hosts the annual Industry Alliance Meeting to present current research results to sponsor companies.
McGill #2 laboratory rice mill
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Products/Byproducts of Rice Milling

- Hulls: 20%
- Bran: 8%
- Brokens: 7%
- Head Rice: 65%