Physical and Functional Characteristics of Broken Rice Kernels

Rebecca M. Bruce
University of Arkansas
Advisor: Dr. Griffiths G. Atungulu

Broken rice facts

- Reduced economic value
- Undesirable Losses
- Inexpensive

Affects Rice end-use functionality

Production of broken rice 14-10%
Arkansas Paddy rice production 5,350,198 MT (USDA, 2016)
Estimated Broken rice production 535,019.8 MT

The Milling Process

- Rough rice
- Brown rice
- Milled rice
- Head rice
- Dehulling
- Milling
- Separation of millrun rice

Parboiling Process
- Rough rice
- Nutrient dense
- Clean
- Increased Head rice yield
- Soak in hot water
- High value
- Steam
- Dry
- Mill

Industrial Applications of brokens
There is a growing market for rice flour.

Rice kernel is not uniform in its properties and composition.

How starch cook

Figure 1. Changes in starch granule during gelatinization as reflected by the viscosity profile. Source: (Thomas and Atwell 1999)

Figure 2. RVA viscosity profile. Source: (Haase et al. 1995)

Problem Statement

• The brokens used for flour consist of different degrees of breakage (differ in sizes)

• From a comingled rice lot comprising of several cultivars

• The characteristics of brokens affect the quality of processed products

Problem Statement

• Inadequate information on broken rice functionality

• Commercial milling streams
  • Regular (non-parboiled)
  • Parboiled brokens

Justification

• Information on the production of high quality broken rice flour

• Science-based knowledge for improved utilization of broken rice kernels

• Improve end-use processes that utilize the brokens

• Enhance quality of products

• Boost overall value of rice as a commodity and increase net returns to growers
Hypothesis

- The different sizes of broken kernels of different rice cultivars from commercial mills will have different pasting properties since the fractures are due to a combination of different factors.

Objectives

- The effect of size characterization of broken on pasting properties of parboiled and regular broken rice.
- The implications of comingling broken of different sizes on pasting properties.
- The effect of moisture content before parboiling on the pasting property of parboiled broken.

MATERIALS AND METHODS

- Paddy Rice (6 cultivars)
- Drying @ 25°C
- Milling
- Classification of broken kernels (size grading using screens)
- Grinding
- Broken rice from commercial mill (Regular and parboiled)
- Pasting property determination (RVA)

Size Separation

- Sieve shaker
- Large (SN 10)
- Medium (SN 12)
- Small (SN 20)

Equipment:
- Rapid Visco Analyzer
- Kjeldahl digestor
- Kjeldahl distillation unit

Figure 3. A flow chart of the methodology.
EXPERIMENT 1
How size influences pasting properties in commercial comingled rice

**Conventional Industrial Rice**
- A mixture of long grain hybrids
- Cultivars: XL 745, XL 753

<table>
<thead>
<tr>
<th>Sample name</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole kernels</td>
<td>6.42</td>
</tr>
<tr>
<td>Large brokens</td>
<td>6.17</td>
</tr>
<tr>
<td>Medium brokens</td>
<td>6.66*</td>
</tr>
<tr>
<td>Small brokens</td>
<td>6.73*</td>
</tr>
</tbody>
</table>

**Viscosity/\(cP\)**
- **Peak Viscosity**
  - WK: whole kernel
  - L: large brokens
  - M: medium brokens
  - S: small brokens
- **Setback Viscosity**
  - WK: whole kernel
  - L: large brokens
  - M: medium brokens
  - S: small brokens

**Final Viscosity**
- L: Large brokens
- M: Medium brokens
- WK: Whole kernels
- S: Small brokens
- L+S: Large and Medium brokens

**Key**
- a: Significantly different from all others
- b: Significantly different from S, L+S, M
- c: Significantly different from L, L+S, M
- d: Significantly different from WK, S, L+S, M
EXPERIMENT 2
The effect of moisture content before parboiling on the pasting property of parboiled brokens

Parboiling condition of rice

- Fresh rice ----------- 18% MC
- Aged rice ----------- 12.5% MC

Industrial Parboiled XL 745

<table>
<thead>
<tr>
<th>Sample name</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Parboiled whole kernels</td>
<td>6.55</td>
</tr>
<tr>
<td>Parboiled whole kernels</td>
<td>7.0*</td>
</tr>
<tr>
<td>Parboiled large brokens</td>
<td>6.78*</td>
</tr>
<tr>
<td>Parboiled medium brokens</td>
<td>6.92*</td>
</tr>
<tr>
<td>Parboiled small brokens</td>
<td>7.48**</td>
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</tbody>
</table>
**Industrial Parboiled XL 745**

<table>
<thead>
<tr>
<th>Size Fractions</th>
<th>Viscosity/cP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>1000</td>
</tr>
<tr>
<td>HL</td>
<td>900</td>
</tr>
<tr>
<td>LM</td>
<td>800</td>
</tr>
<tr>
<td>LLS</td>
<td>700</td>
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<td>HM</td>
<td>600</td>
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<tr>
<td>HLS</td>
<td>500</td>
</tr>
<tr>
<td>LS</td>
<td>400</td>
</tr>
<tr>
<td>HS</td>
<td>300</td>
</tr>
</tbody>
</table>

**Discussion of Result**

- Aged rice has lower water uptake \((\text{Sodhi et al., 2003})\)

- Decreased water absorption could be due to rearrangement of starch granules and the combination of starch and other substances in rice bran \((\text{Inprasit 2001})\)

- Proteins may have greater influence than amylose on parboiled rice properties

- Varietal differences in rice aging

**EXPERIMENT 3**

How size influences the pasting properties of rice flour (laboratory generated brokens)

**Results and Discussions**

- Size has a significant effect on peak viscosity, final viscosity, breakdown, trough \((p\text{-value}<0.05)\)

- Size has no significant effect on pasting temperature, peak time, setback \((p\text{-value}>0.05)\)
**Ongoing Work**

- Identify more intrinsic properties of broken rice
- Explain observed trends
- Formulate high premium broken rice flour for specific end uses

**Conclusion**

- Larger brokens had better pasting properties than smaller brokens
- Comingling of large and small brokens produce viscosity similar to either medium or small brokens (Cultivar dependent)
- Rice parboiled at 12.5% MC has better pasting property than 18% MC
References


Acknowledgments

Dr. Griffith G. Atungulu