Soft and Hard Wheat Milling

U.S. WHEAT ASSOCIATES
The world’s most reliable choice.

22nd IAOM - Middle East and Africa Hashemite Kingdom of Jordan
October 2011
Thanks and Acknowledgements

• Henry Stevens – for his wonderful 2000 paper on this subject to the AOM, much of which is recycled here.
• Dr. Craig Morris and the Agricultural Research Service of the USDA for the great SEM photos.
• The Buhler Group for their photos and contribution of materials for this presentation.
• Dick Prior – for inviting me 😊
• Sciencephotolibrary.com for the wonderful wheat photo.
Scope of this presentation

- Physical differences
- Milling Differences
- Expectations
Fraternal greetings from the millers of North Africa who cannot be with us today.
‘HARDNESS’ defined

1. The property of being rigid and resistant to pressure
2. The state or quality of being hard: *the hardness of ice.*
3. A relative degree or extent of this quality: wood of a desirable hardness.
4. Mineralogy. The comparative ability of a substance to scratch or be scratched by another.
5. Metallurgy. The measured resistance of a metal to indentation, abrasion, deformation, or machining. *This is probably the most fitting definition for milling.*
- Bran
- Aleurone
- Endosperm
So – what are the differences between hard and soft wheat?

- **Difference is in physical hardness or resistance to compression forces.**
  - Is **not** correlated to vitreosity. \( R^2 \) of 0.18
  - Hardness IS correlated to protein. \( R^2 = 0.62 \)
  - And to whole wheat ash \( r = -0.55 \)*
  - And to semolina yield \( 0.52 \)*
  - And to flour Protein \( 0.42 \)* by inference with wheat protein.
  - And Zeleny sedimentation \( 0.32 \)*
  - And Starch damage.
  - And Flour granulometry.
  - And rollermill power.
  - And sifter throughput.

* Wheat Hardness in Relation to Other Quality Factors
  Marie HRUŠKOVÁ and Ivan ŠVEC
Some scientific references.

INCREASING WHEAT HARDNESS LOCUS FUNCTIONALITY BY INCREASING Puroindoline COPY NUMBER AND INTRODUCTION OF NOVEL ALLELES

by Jackie Bridget Campbell

STRUCTURAL BASIS OF WHEAT HARDNESS AND TECHNOLOGICAL CONSEQUENCES*

J. Abecassis, M. Chaurand, J.-C. Autran

ENSA-INRA, UFR de Technologie des Céréales et des Agropolymères, 2 place P. Viala 34060 Montpellier Cedex, France

Accepted October 15, 1997

Wheat Hardness in Relation to Other Quality Factors

MARIE HRUŠKOVÁ and IVAN ŠVEC

Department of Carbohydrate Chemistry and Technology, Faculty of Food and Biochemical Technology, Institute of Chemical Technology in Prague, Prague, Czech Republic

Vol. 27, 2009, No. 4: 240–248
Wheat grain hardness results from highly conserved mutations in the friabilin components puroindoline a and b

- “Soft” and “hard” are the two main market classes of wheat (Triticum aestivum L.) and are distinguished by expression of the Hardness gene.
- Friabilin, a marker protein for grain softness (Ha), consists of two proteins, puroindoline a and b (pinA and pinB, respectively).

Proc. Natl. Acad. Sci. USA
Vol. 95, pp. 6262–6266, May 1998
Genetics

MICHAEL J. GIROUX & CRAIG F. MORRIS
Hardness to Protein - US Wheat classes

PROTEIN TO HARDNESS

n = 3837
R² = 0.62
Hardness to Protein - US Wheat classes

PROTEIN TO HARDNESS

- Hard wheats
- Soft wheats

n = 3837

R^2 = 0.62
To millers it is a question of:

• What is the ideal tempering time to permit the most complete separation of components.

• How strongly bonded the endosperm granules are – by the ‘interstitial protein’.

• How densely packed are the endosperm granules.

• How much compressive force is needed to reduce the granules to flour.
Getting to the point!
Soft (L) wheat endosperm and Hard (R) Wheat
A. Soft and B. Hard wheat flour
• Now we know what hardness is – how do we measure it?
The old millers knew about hardness.

But, biting the wheat was subjective and difficult to reproduce.
The Single Kernel Characterization System from Perten Instruments.

- Objective method to determine hardness.
  - And tempering time.
  - And grinding pressure.
  - And sifter surface.
The Perten Single Kernel Characterization System or SKCS

© Perten instruments & others
Using the SKCS

Establishing the baseline for your optimum time tests

SKCS hardness

4 Hrs

30 Hrs
Very simplistic description of the function of the SKCS

- Kernels held in place by vacuum
- Weigh kernel
- Sample
- Moisture
- Diameter
- Crushing force
The Tempering Process

- **Hard Wheats = Osmosis (SLOW)**
- **Soft Wheats = Capillary Action (FAST)**

Density or Space between Starch granules
Test milling - straight grade ash vs. temper time

\[ y = 0.0036x^2 - 0.1243x + 1.5309 \]

\[ R^2 = 0.9341 \]

This wheat is best milled between 14 and 20 hrs.
With a tolerance between 12 and 24 hrs.
It tolerates overtempering better than undertempering.
Objectives of the Grinding process

• **Break system**
  – Shearing force.
  – Separates components of wheat.

• **Reduction system**
  – Compressive force.
  – Reduces semolina to flour.
Reduction System: Compressive force

Break System: Shear force

Difference in function

Separation easy

Separation very difficult to impossible!
Hard Wheat  The Sifting Process  Soft Wheat

agglomerates
Process of agglomeration – soft flour

- Mix of granules and clusters.
- Natural attraction of fine particles.
- Agglomerated composites.
Soft wheat does not sift as easily

- Agglomerates of low density do not sift as easily as free flowing granular products.

- Soft wheat produces finer flour particles which agglomerate. Hard wheat produces coarser products which do not agglomerate.

- Measured in Kg/Sq.M/Hour of sifter material.

- Soft wheat mills need more Square Meters of sifter area.
Throughput examples

**Plansifter - kg/SqM/Hr**

- **B1 - Hard Wheat**
- **B1 - Soft Wheat**
- **B3 - Hard Wheat**
- **B3 - Soft Wheat**
## Whitby 1958

### TABLE I

Percent Flour Passing Through U.S. Standard 120-Wire Sieve Versus Time (58% rh)

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Hard Wheat</th>
<th>Soft Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent Through Sieve</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>5</td>
<td>7.3</td>
<td>1.8</td>
</tr>
<tr>
<td>10</td>
<td>13.0</td>
<td>3.8</td>
</tr>
<tr>
<td>20</td>
<td>24.5</td>
<td>6.0</td>
</tr>
<tr>
<td>30</td>
<td>34.3</td>
<td>8.1</td>
</tr>
<tr>
<td>40</td>
<td>44.8</td>
<td>10.9</td>
</tr>
<tr>
<td>50</td>
<td>53.3</td>
<td>12.7</td>
</tr>
<tr>
<td>60</td>
<td>61.3</td>
<td>13.8</td>
</tr>
<tr>
<td>70</td>
<td>67.5</td>
<td>14.4</td>
</tr>
<tr>
<td>100</td>
<td>70.5</td>
<td>14.3</td>
</tr>
</tbody>
</table>
Conclusions of their study:

The sieving index for hard and soft wheat flour was controlled by the cohesiveness of the flour system. The bulking number and bridging threshold tests identified that moisture content, presence or absence of fat, or particle size distribution and particle surface roughness, were involved in flour cohesion. Hard and soft wheat flour did not have the same sieving indexes until these four characteristics were held at equivalent values.
Hard Wheat needs more power to grind

- Physical grinding of hard wheat semolina into flour needs more power.
- Also, more composite particles are produced needing purification, and scratch or sizings passages to break up composite particles for purification.
### Determination of Roll horsepower:

\[
Pt(Kw) = (Q \times K) \times K1 \times K2 \times K3 \times K4 + Pv
\]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt</td>
<td>Roll power in Kilowatts (consumed)</td>
</tr>
<tr>
<td>Q</td>
<td>Stock quantity in Kg/min</td>
</tr>
<tr>
<td>K</td>
<td>Grinding power coefficient for passage</td>
</tr>
<tr>
<td>K1</td>
<td>Coefficient for power factor and mechanical losses</td>
</tr>
<tr>
<td>K2</td>
<td>Wheat hardness coefficient</td>
</tr>
<tr>
<td>K3</td>
<td>Ambient temperature coefficient</td>
</tr>
<tr>
<td>K4</td>
<td>Location Altitude coefficient</td>
</tr>
<tr>
<td>Pv</td>
<td>Rollermill power – no load.</td>
</tr>
</tbody>
</table>

Values of coefficient K2 = 1.00 on soft wheat, 1.03 on hard wheat and 1.08 on durum wheat.
A soft wheat diagram
Durum diagram
<table>
<thead>
<tr>
<th>GRIST</th>
<th>SPECIFIC SIFTER AREA M² / 100KG</th>
<th>ROLLERMILL LENGTH MM/100KG</th>
<th>PURIFIER SURFACE MM/100KG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Wheat</td>
<td>0.065</td>
<td>10-11</td>
<td>None</td>
</tr>
<tr>
<td>Hard Wheat</td>
<td>0.055</td>
<td>12-13</td>
<td>6-6.5</td>
</tr>
<tr>
<td>Mixed Diagram</td>
<td>0.065</td>
<td>12-13</td>
<td>6-6.5</td>
</tr>
</tbody>
</table>

European specs.
The Solution – flour blending.
Whatever you mill – we wish you every success and prosperity for the future.

On behalf of us all at US Wheat we thank you for your business, and for your attention today

We wish you an enjoyable conference