اَلمَمْلَكَة اَلأُرْدُنِيّة اَلهَاشِمِيّة

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.**

BÜHLER

USDA ars

U.S. WHEAT ASSOCIATES

The world's most reliable choice.

Scope of this presentation

- Physical differences
- Milling Differences
- Expectations

U.S. WHEAT ASSOCIATES

The world's most reliable choice.

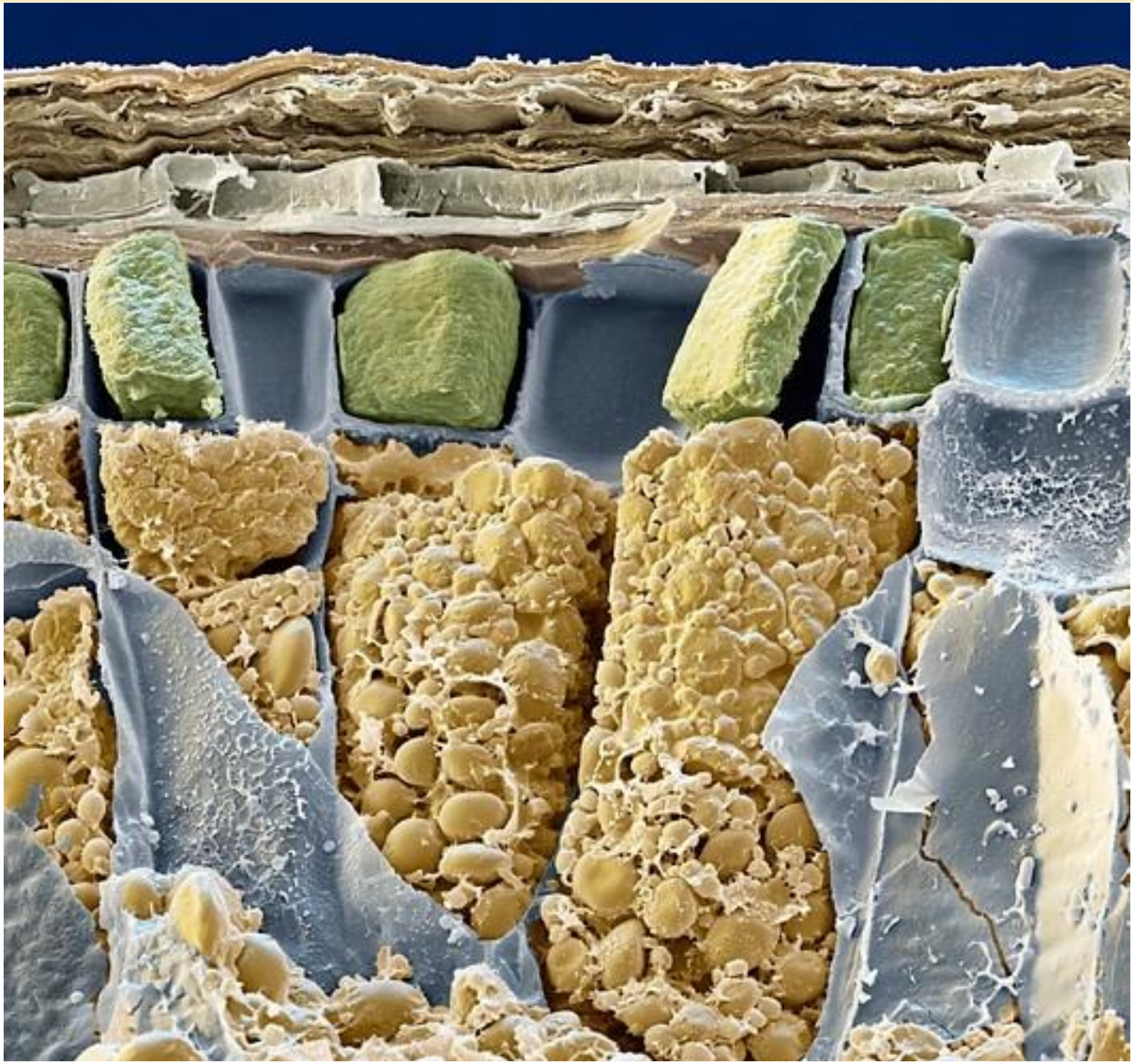
Fraternal greetings from the millers of North Africa who cannot be with us today.

‘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 indention, abrasion, deformation, or machining. This is probably the most fitting definition for milling.**

U.S. WHEAT ASSOCIATES

The world’s most reliable choice.



© sciencephoto.com

- 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=.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

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

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 Agropolyméres, 2 place P. Viala
34060 Montpellier Cedex, France

Accepted October 15, 1997

Vol. 27, 2009, No. 4: 240–248 *Czech J. Food Sci.*

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

U.S. WHEAT ASSOCIATES

The world's most reliable choice.

Wheat grain hardness results from highly conserved mutations in the friabilin components puroindoline a and b

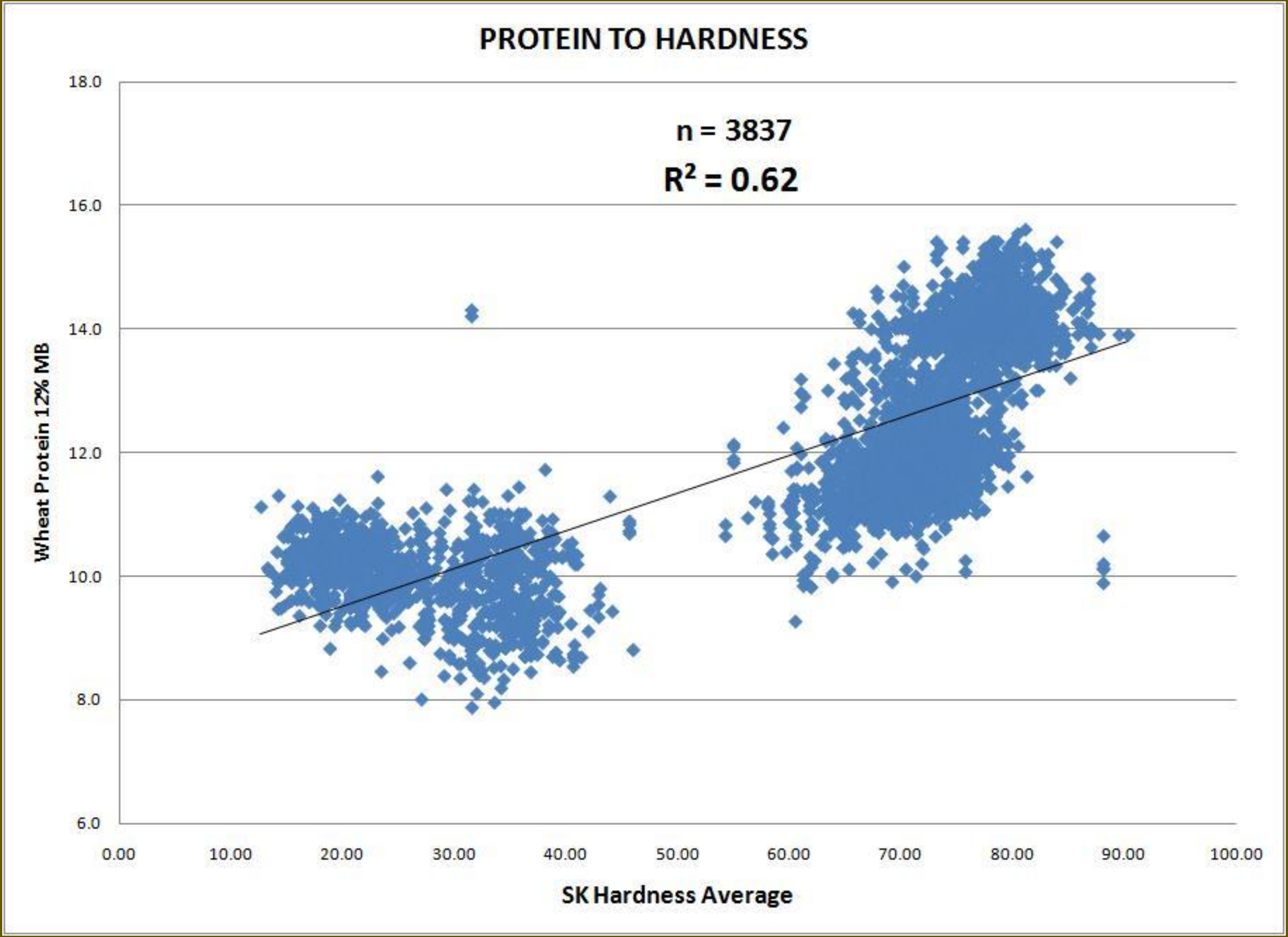
- **“Soft” and “hard” are the two main market classes of wheat (*Triticum aestivum L.) and are distinguished* by expression of the *Hardness gene.***
- ***Friabilin, a marker protein* for grain softness (*Ha), consists of two proteins, puroindoline* a and b (pinA and pinB, respectively).**

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

MICHAEL J. GIROUX &
CRAIG F. MORRIS

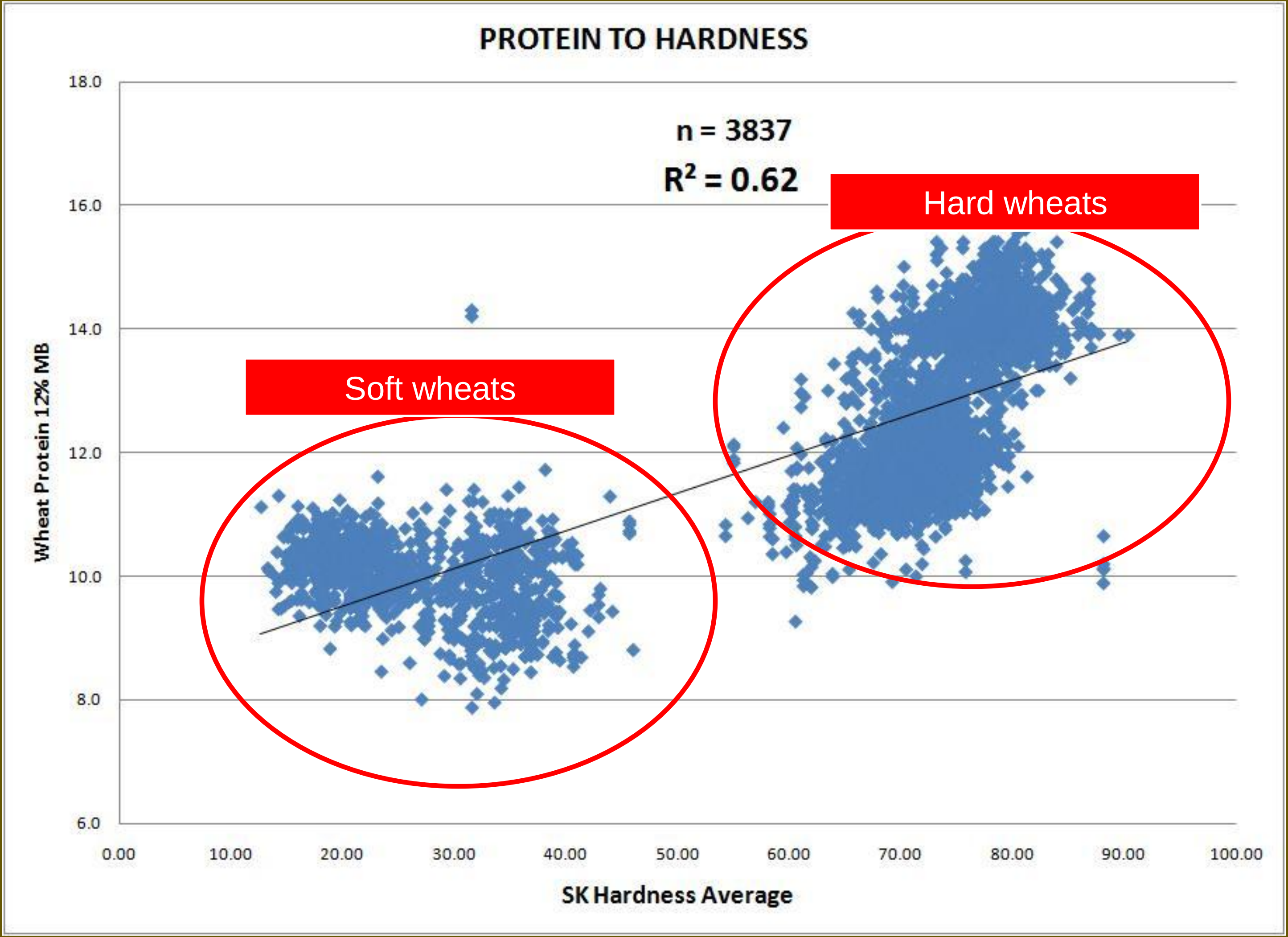
U.S. WHEAT ASSOCIATES
The world's most reliable choice.

Hardness to Protein - US Wheat classes



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

Hardness to Protein - US Wheat classes

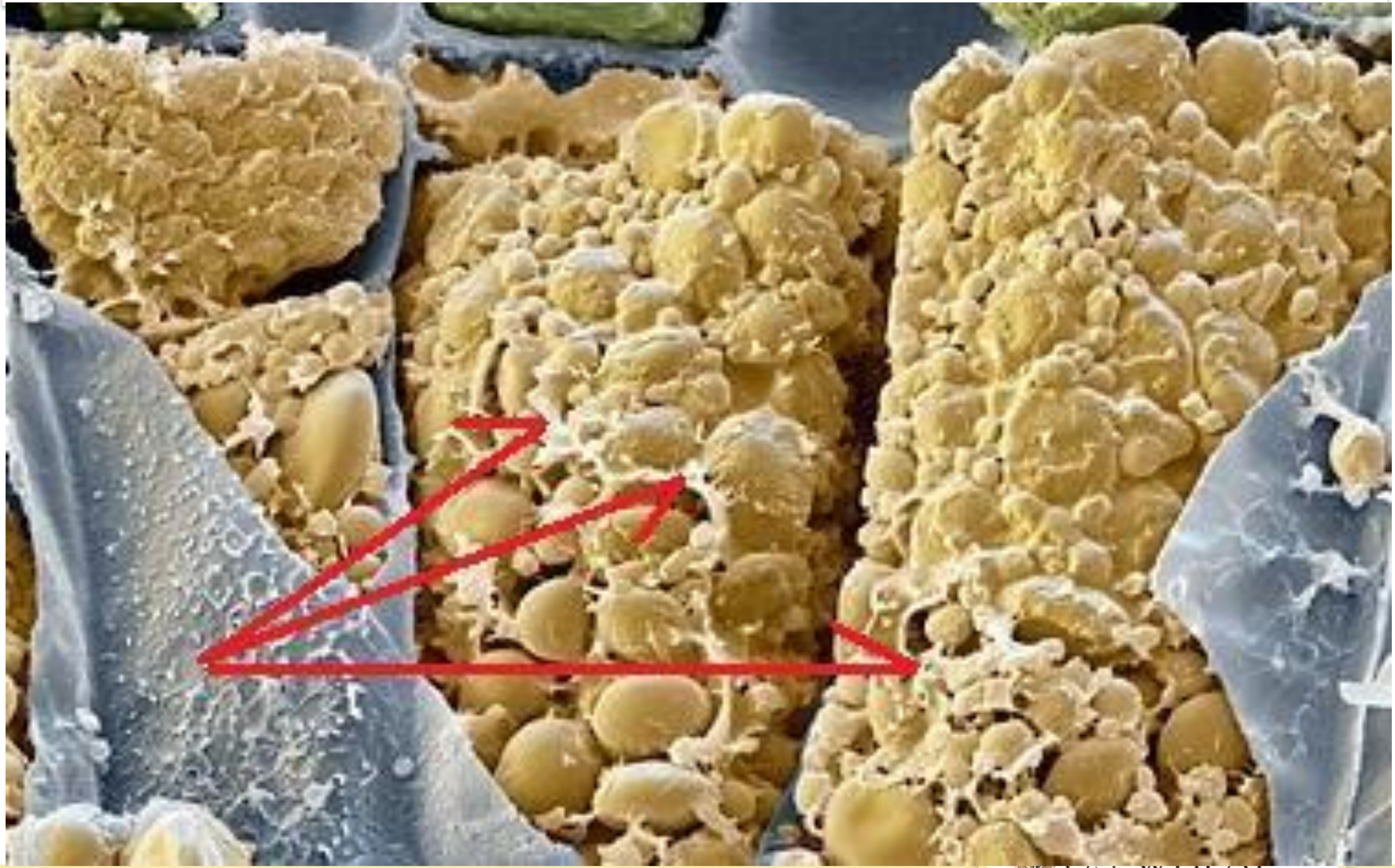


U.S. WHEAT ASSOCIATES
The world's most reliable choice.

To millers it is a question of;

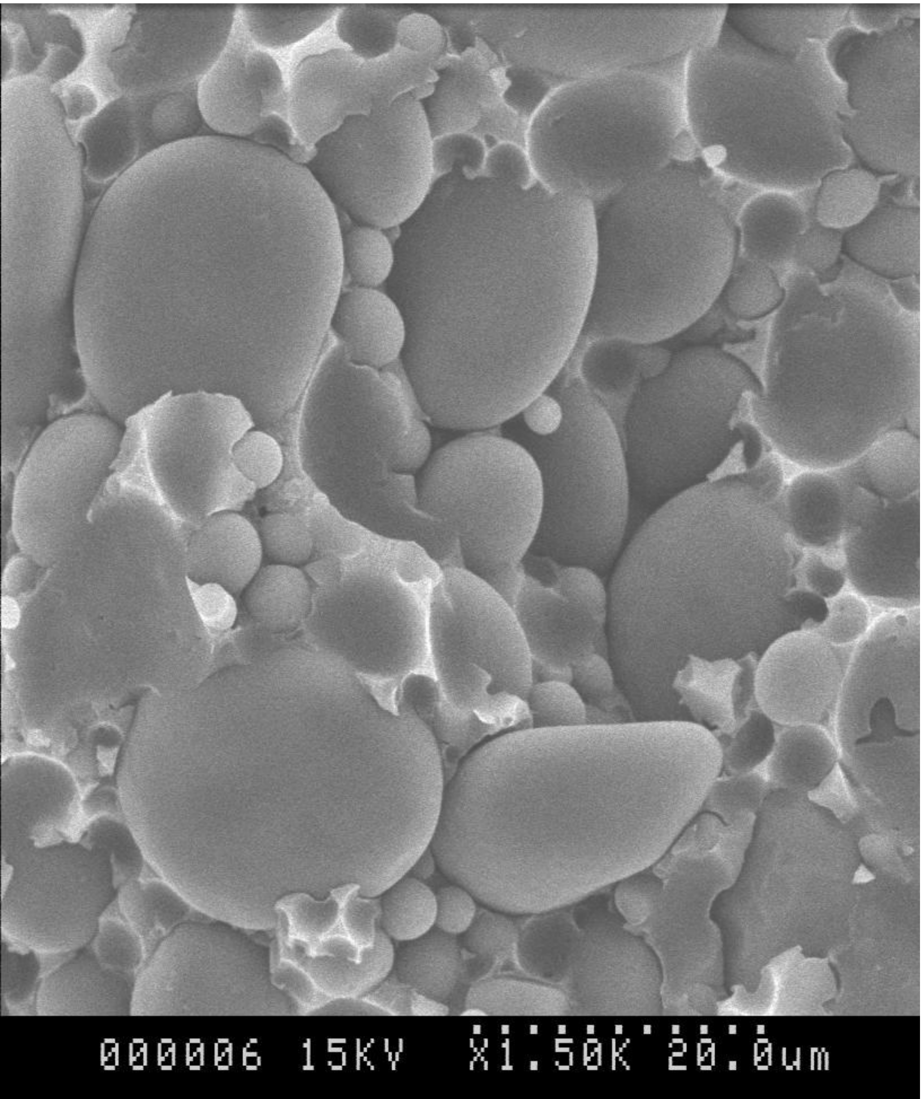
- **What is the ideal tempering time to permit the most complete separation of components.**
- **How strongly bonded the endosperm granules are – by the 'interstitial protein'.**
- **How densely packed are the endosperm granules.**
- **How much compressive force is needed to reduce the granules to flour.**

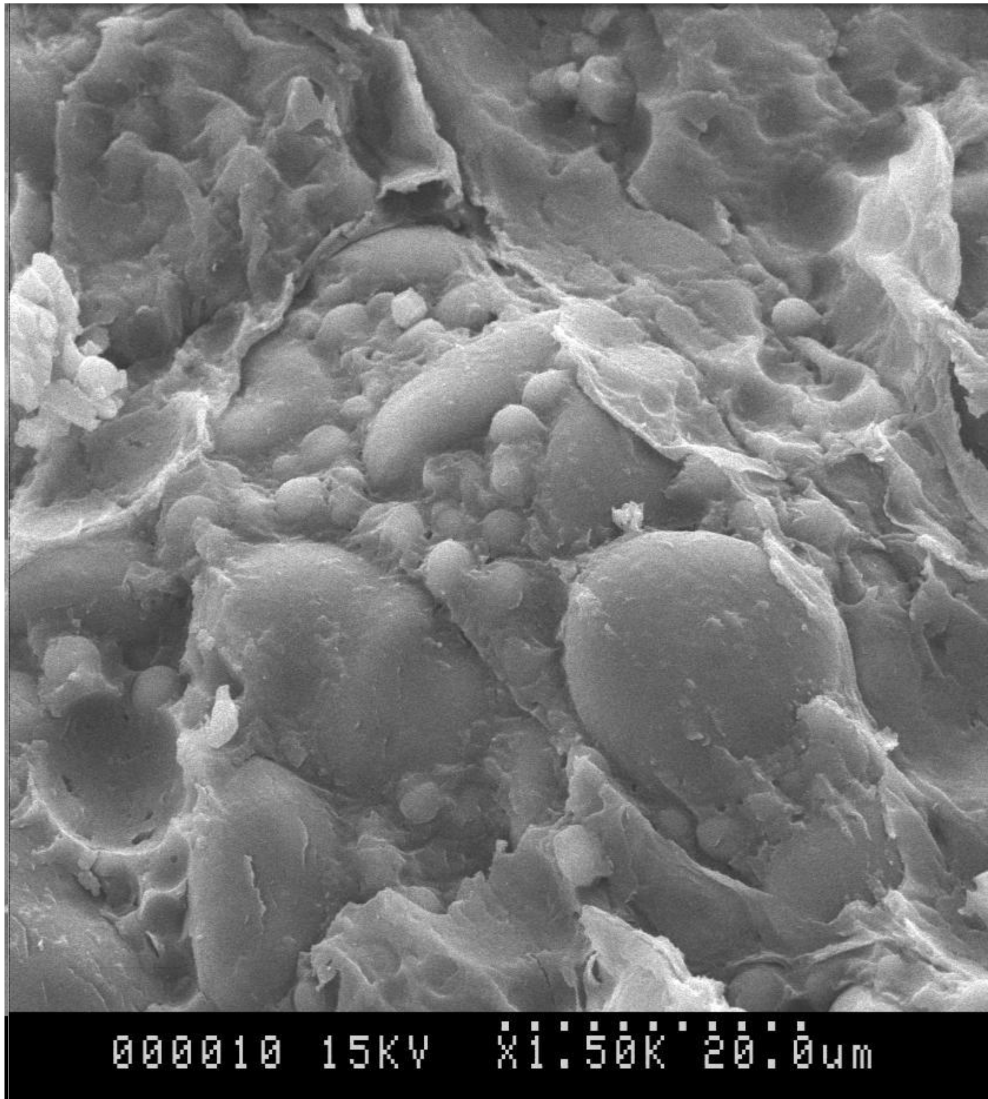
Getting to the point!



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

Soft (L) wheat endosperm and Hard (R) Wheat

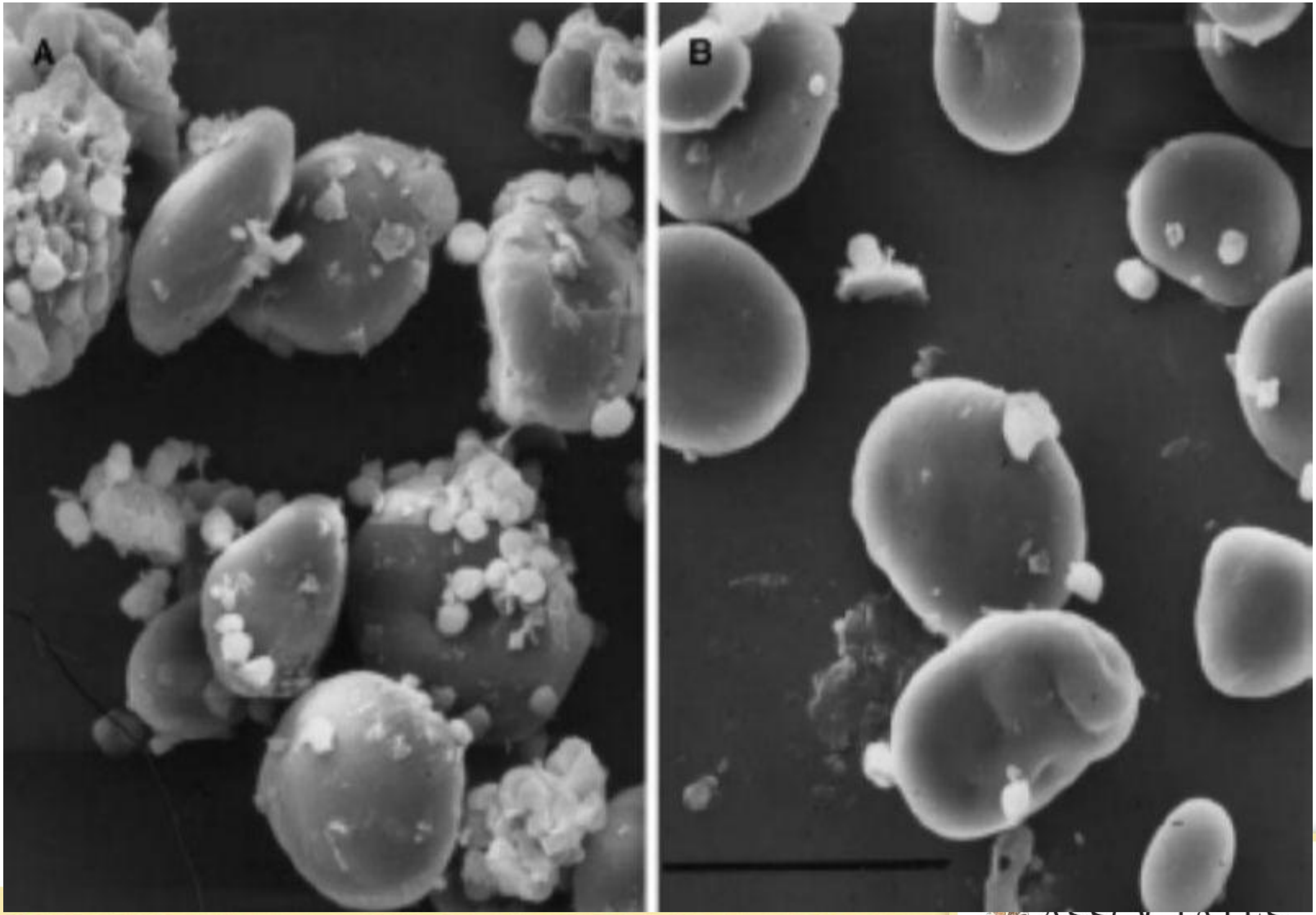




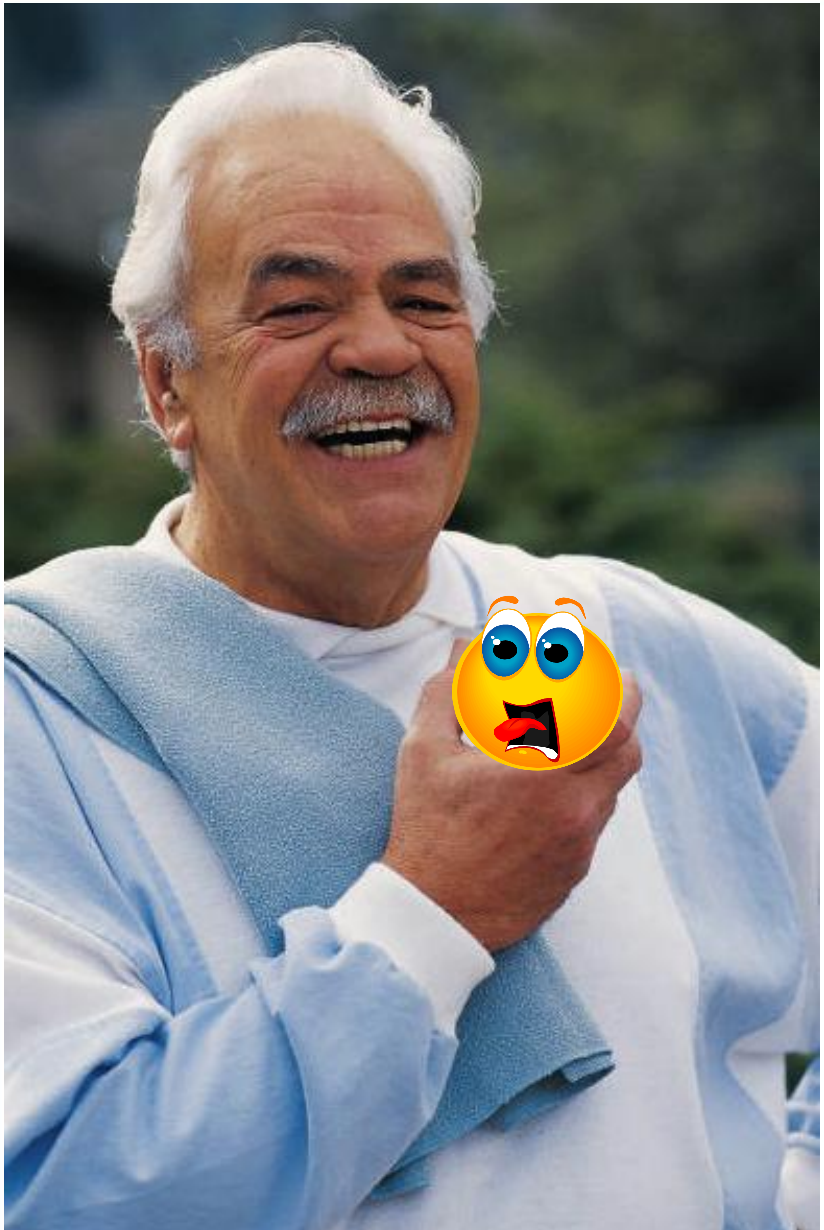
Soft Wheat

Hard 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

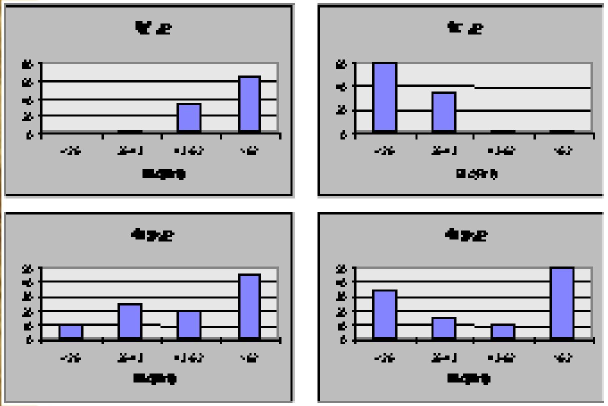
But, biting the wheat was subjective and difficult to reproduce

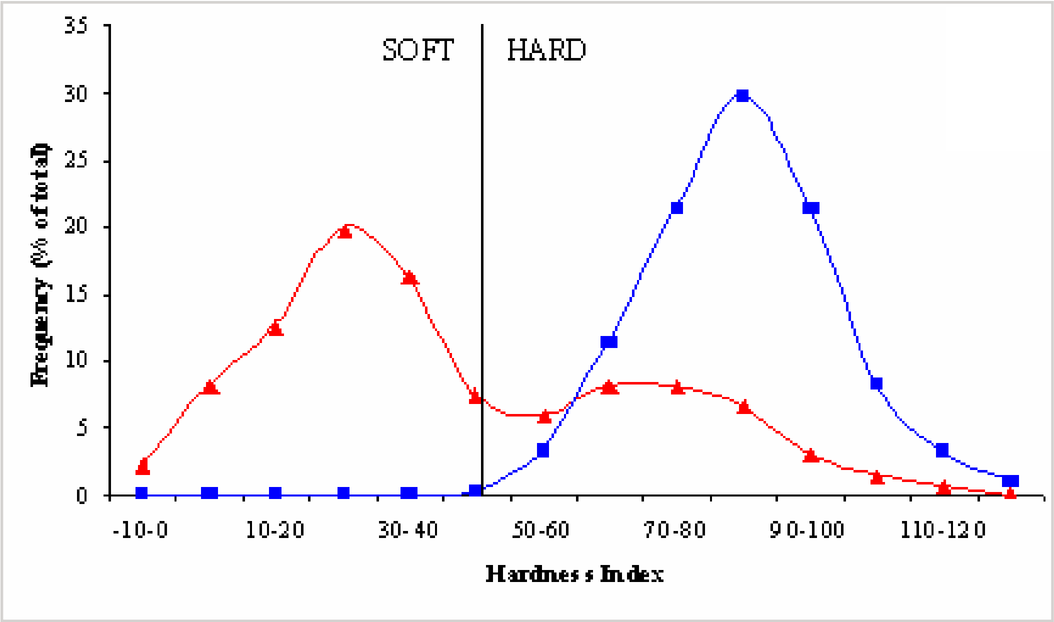
The Single Kernel Characterization System from Perten Instruments.

- **Objective method to determine hardness.**
  - And tempering time.
  - And grinding pressure.
  - And sifter surface.

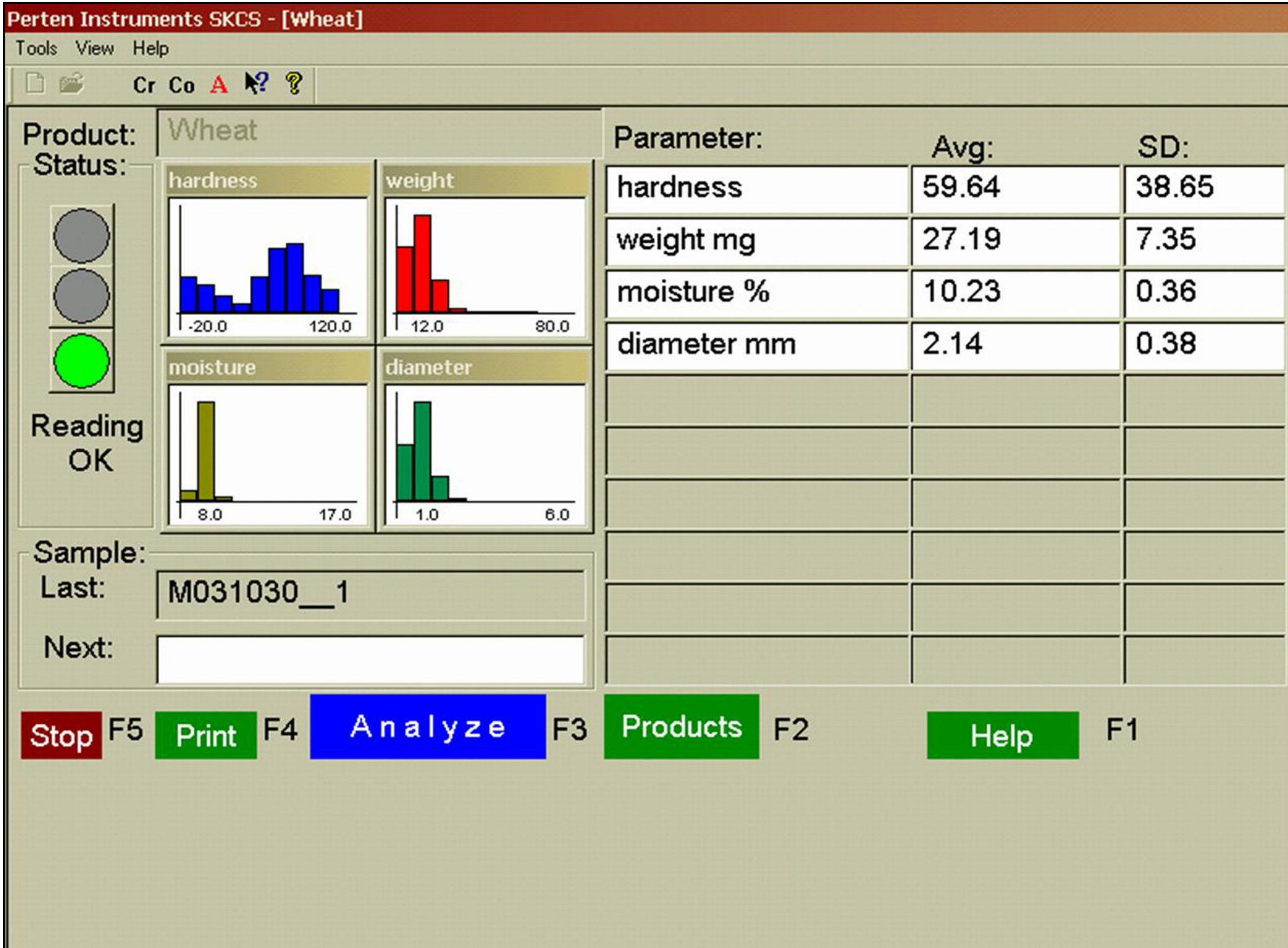
U.S. WHEAT ASSOCIATES
The world's most reliable choice.

The Perten Single Kernel Characterization System or SKCS



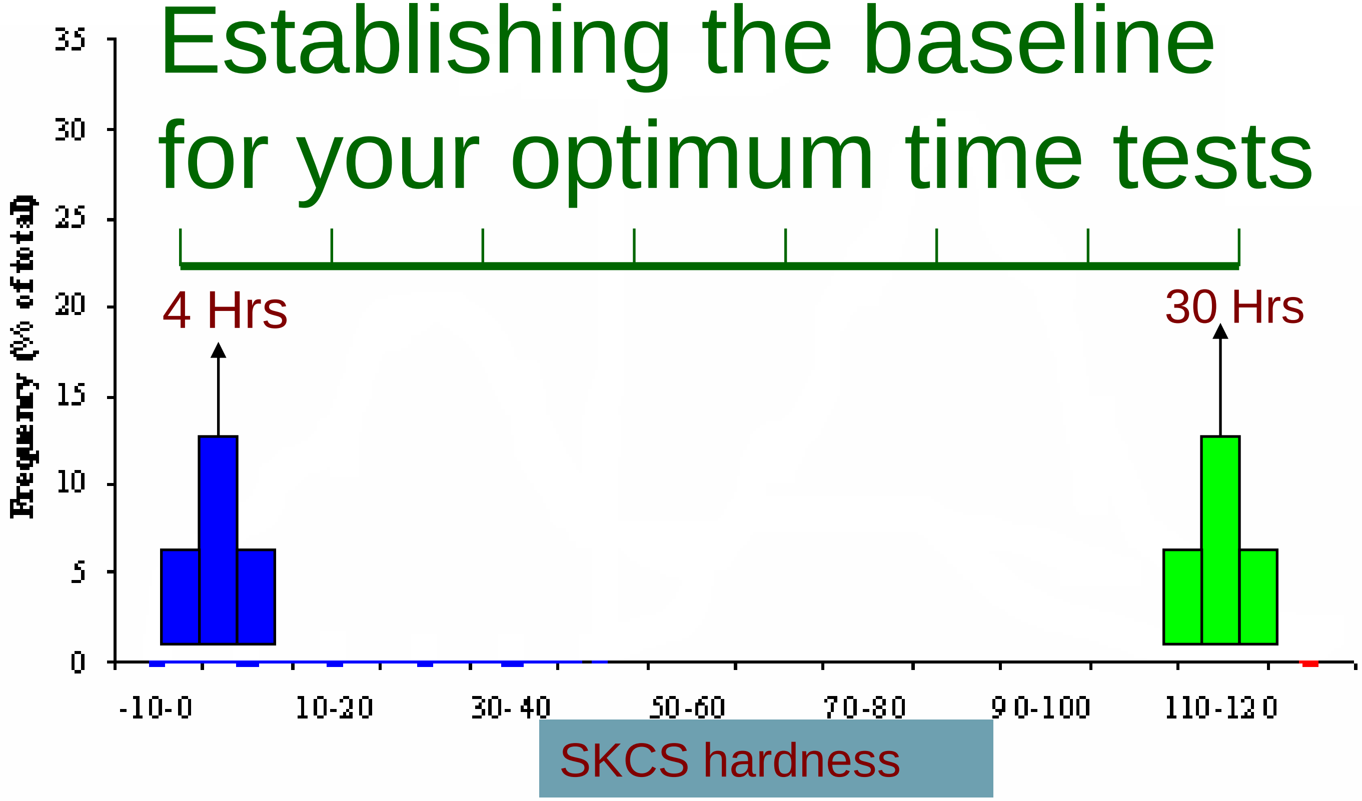


© Perten instruments & others

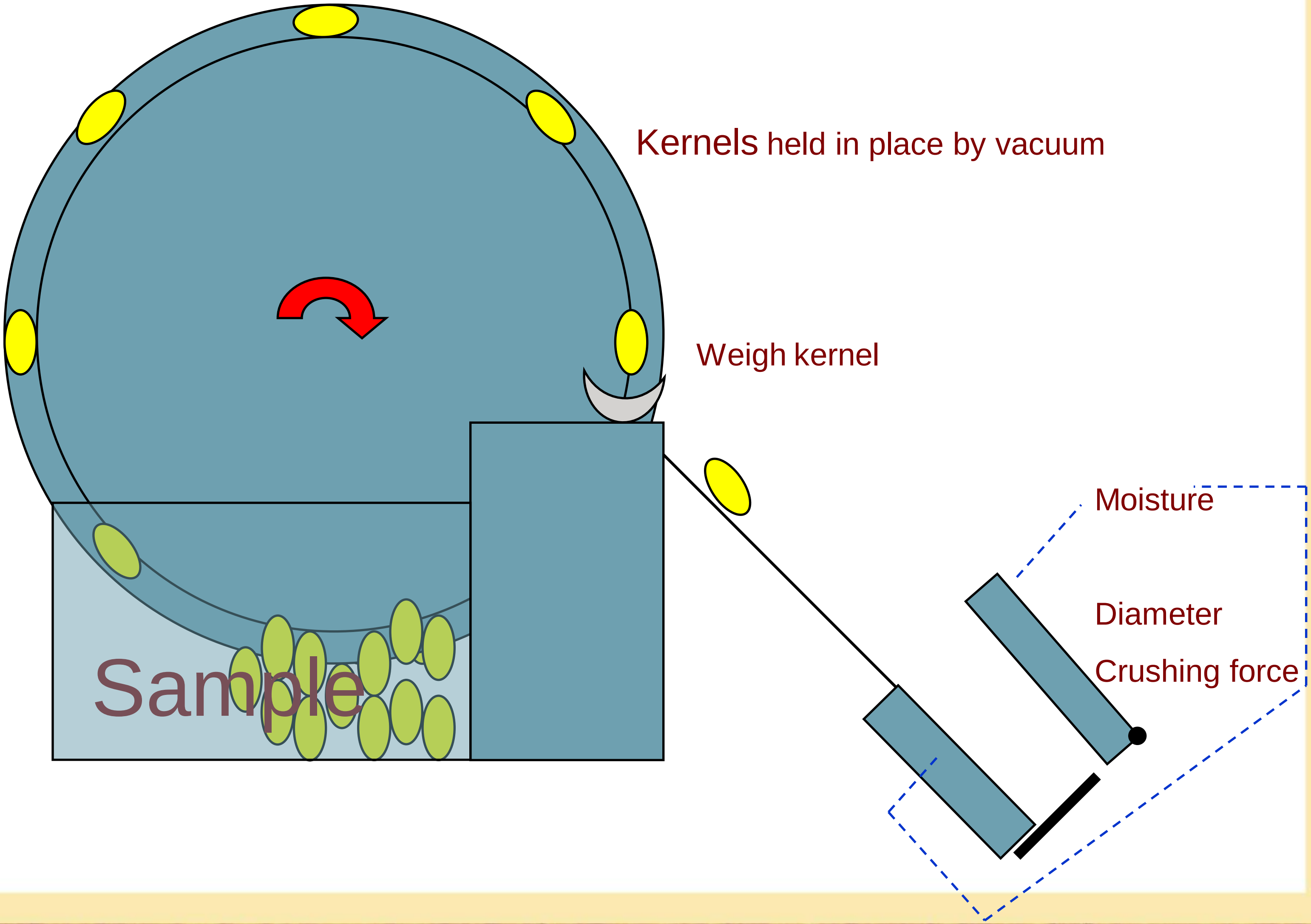

Perten Instruments SKCS - [Wheat]
Tools View Help
Cr Co A
Product:
Wheat
Status:
Reading OK
hardness
-20.0
120.0
weight
12.0
80.0
moisture
8.0
17.0
diameter
1.0
6.0
Parameter:
Avg:
SD:
hardness 59.64 38.65
weight mg 27.19 7.35
moisture % 10.23 0.36
diameter mm 2.14 0.38
Sample:
Last:
M031030__1
Next:
Stop F5
Print F4
Analyze F3
Products F2
Help F1

Using the SKCS

Establishing the baseline for your optimum time tests

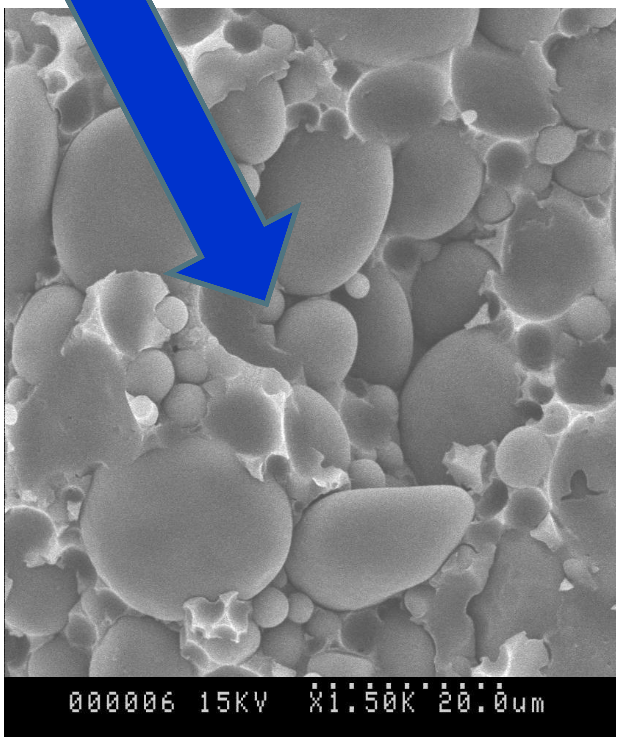


Very simplistic description of the function of the SKCS

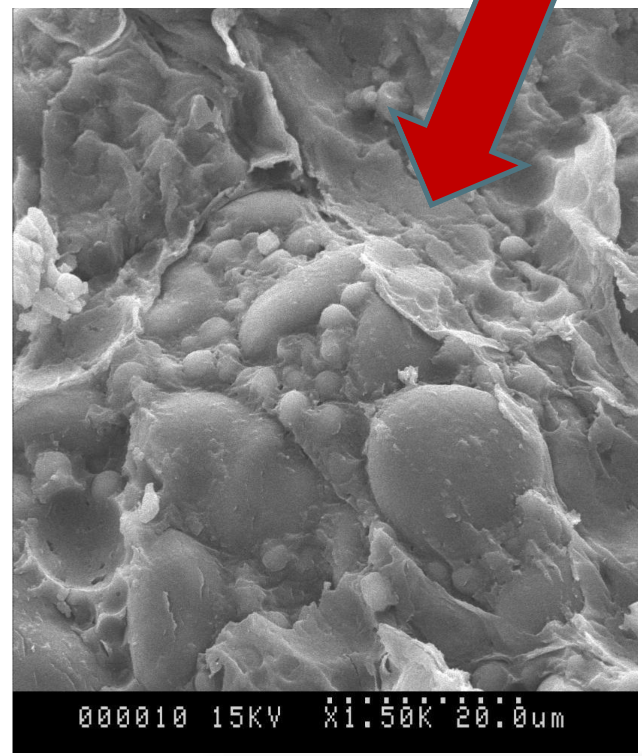


The Tempering Process

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



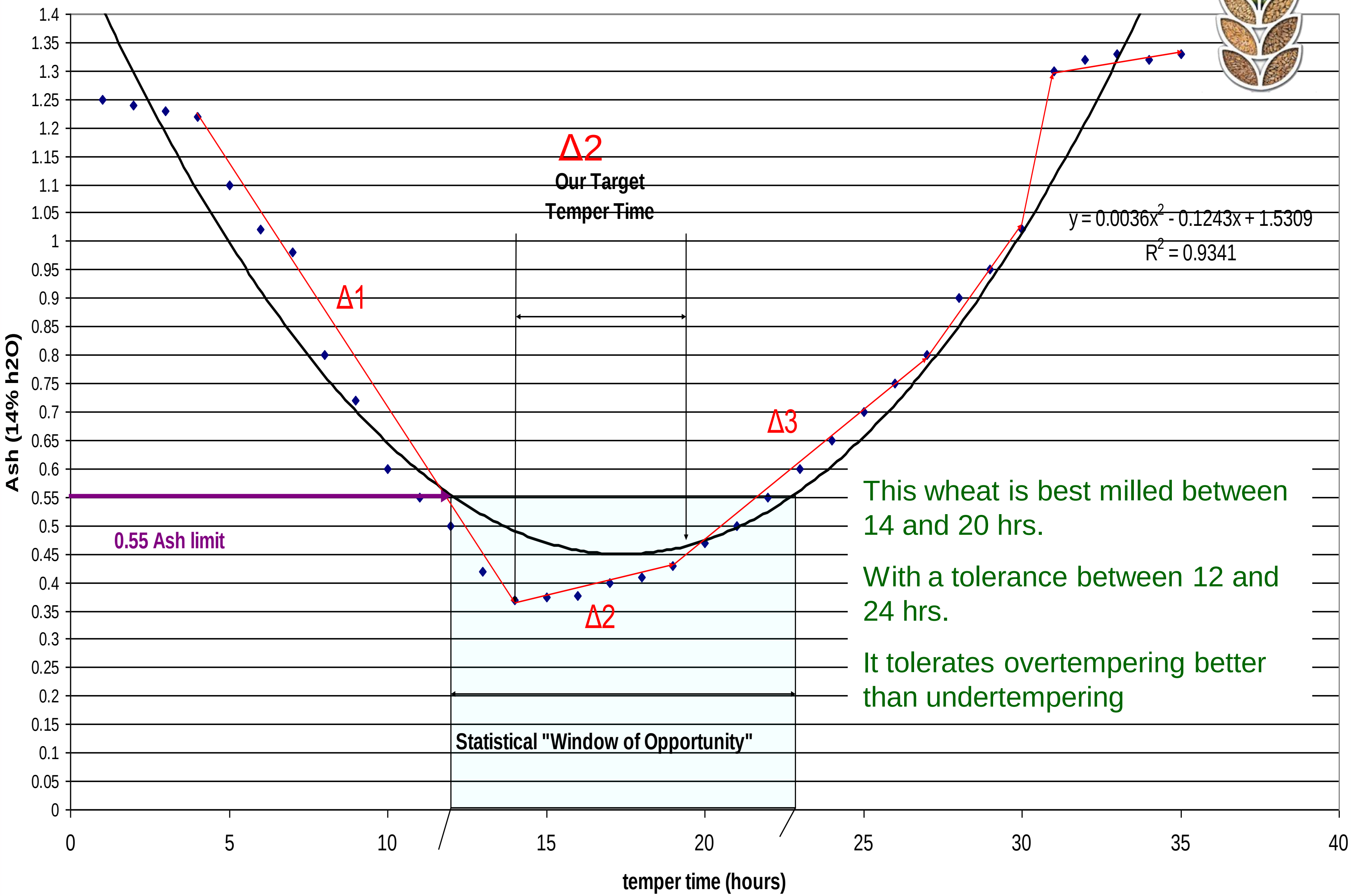
Density or Space between Starch granules



U.S. WHEAT ASSOCIATES

The world's most reliable choice.

Test milling - straight grade ash vs. temper time



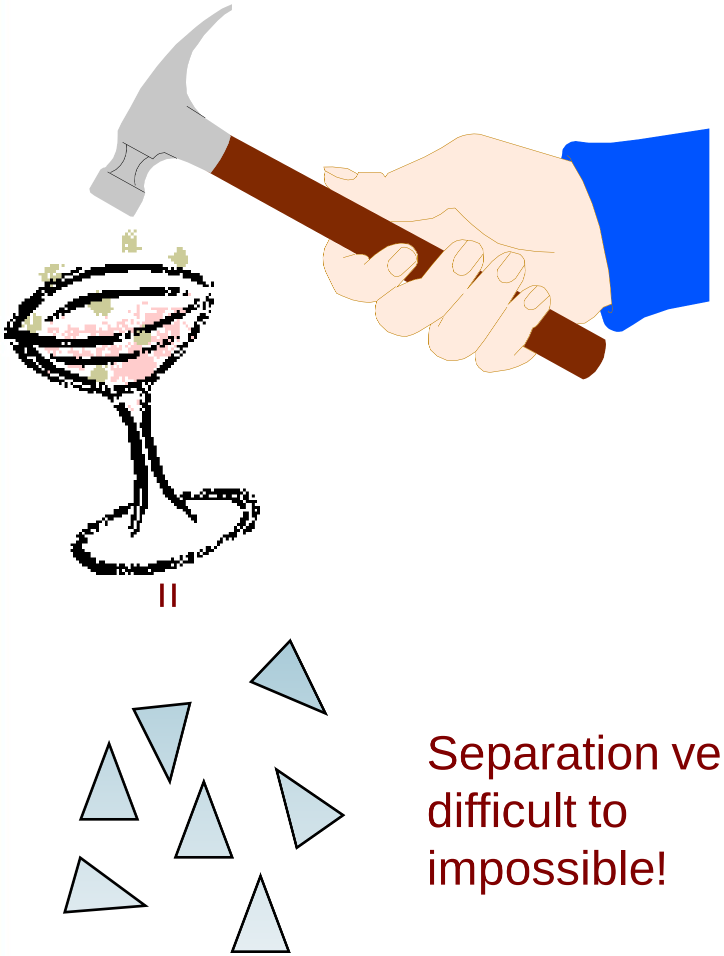
Objectives of the Grinding process

- **Break system**
  - Shearing force.
  - Separates components of wheat.

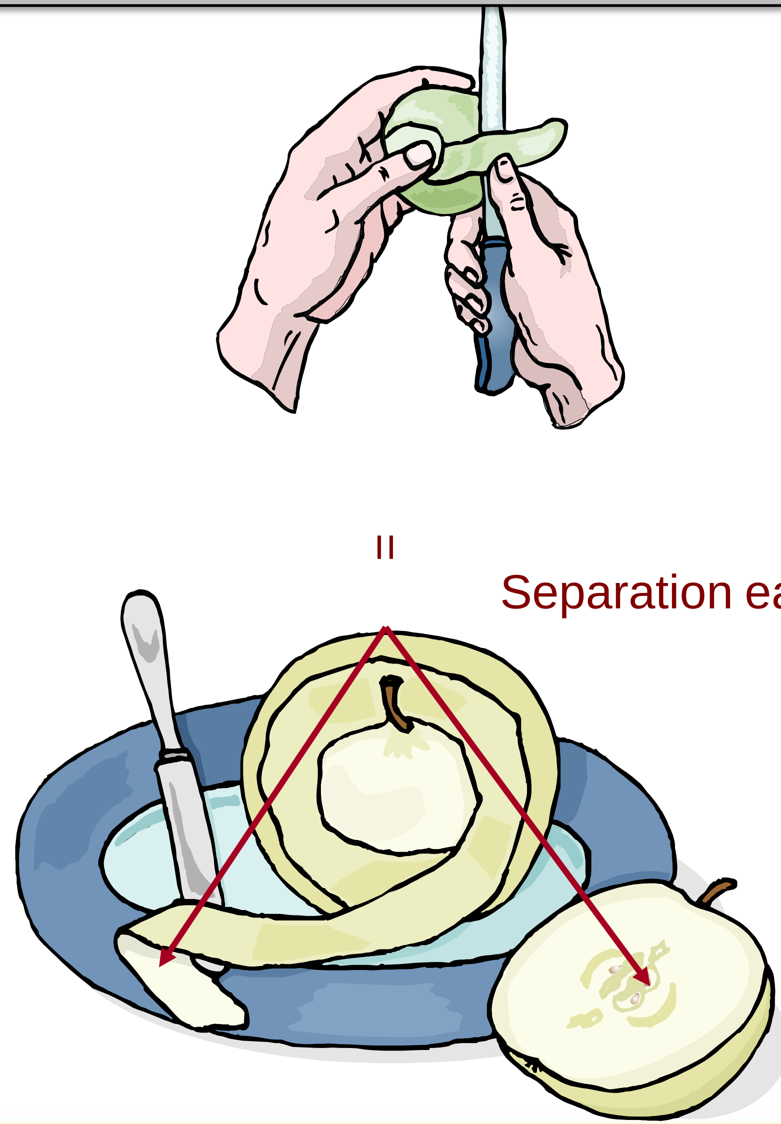
- **Reduction system**
  - Compressive force.
  - Reduces semolina to flour.

Difference in function

Reduction System:Compressive force	Break System:Shear force



Separation very difficult to impossible!

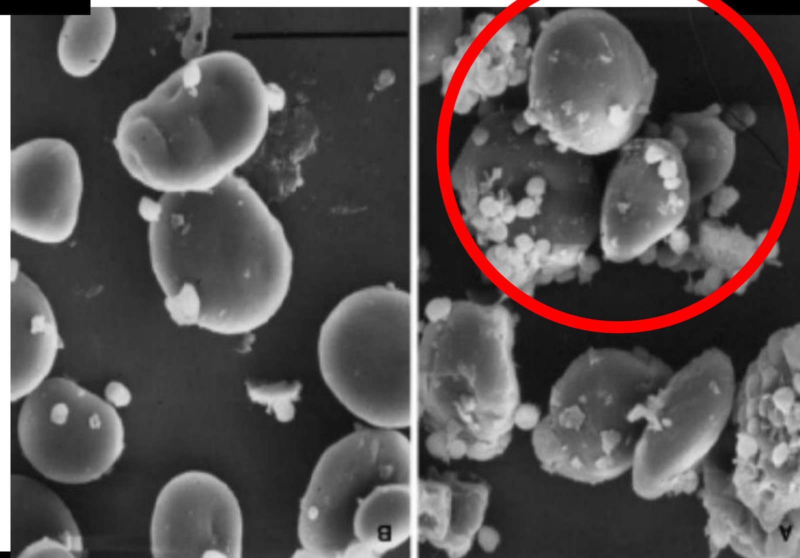


Separation easy

The Sifting Process

Hard Wheat

Soft Wheat



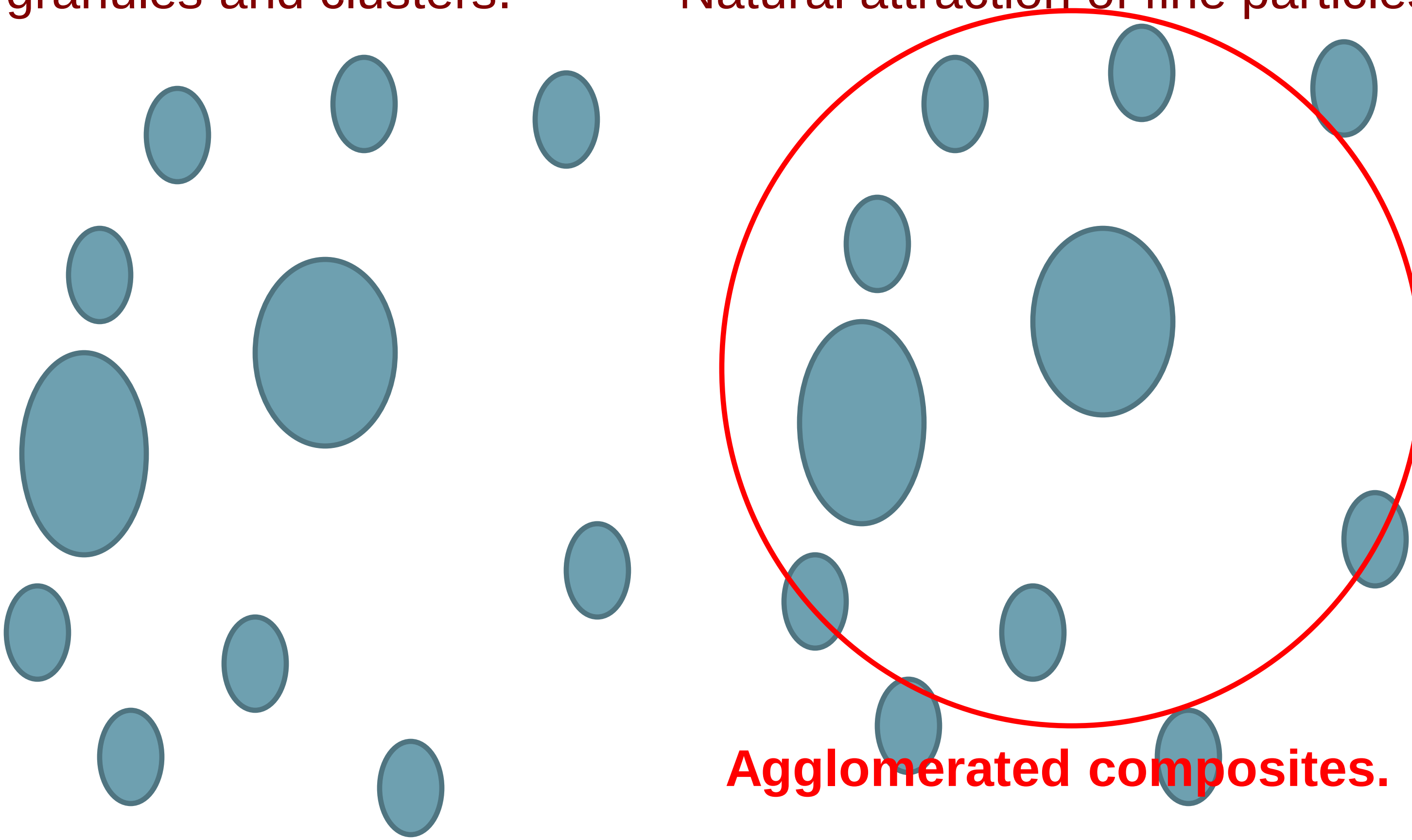
U.S. WHEAT ASSOCIATES

The world's most reliable choice.

Process of agglomeration – soft flour

Mix of granules and clusters.

Natural attraction of fine particles.

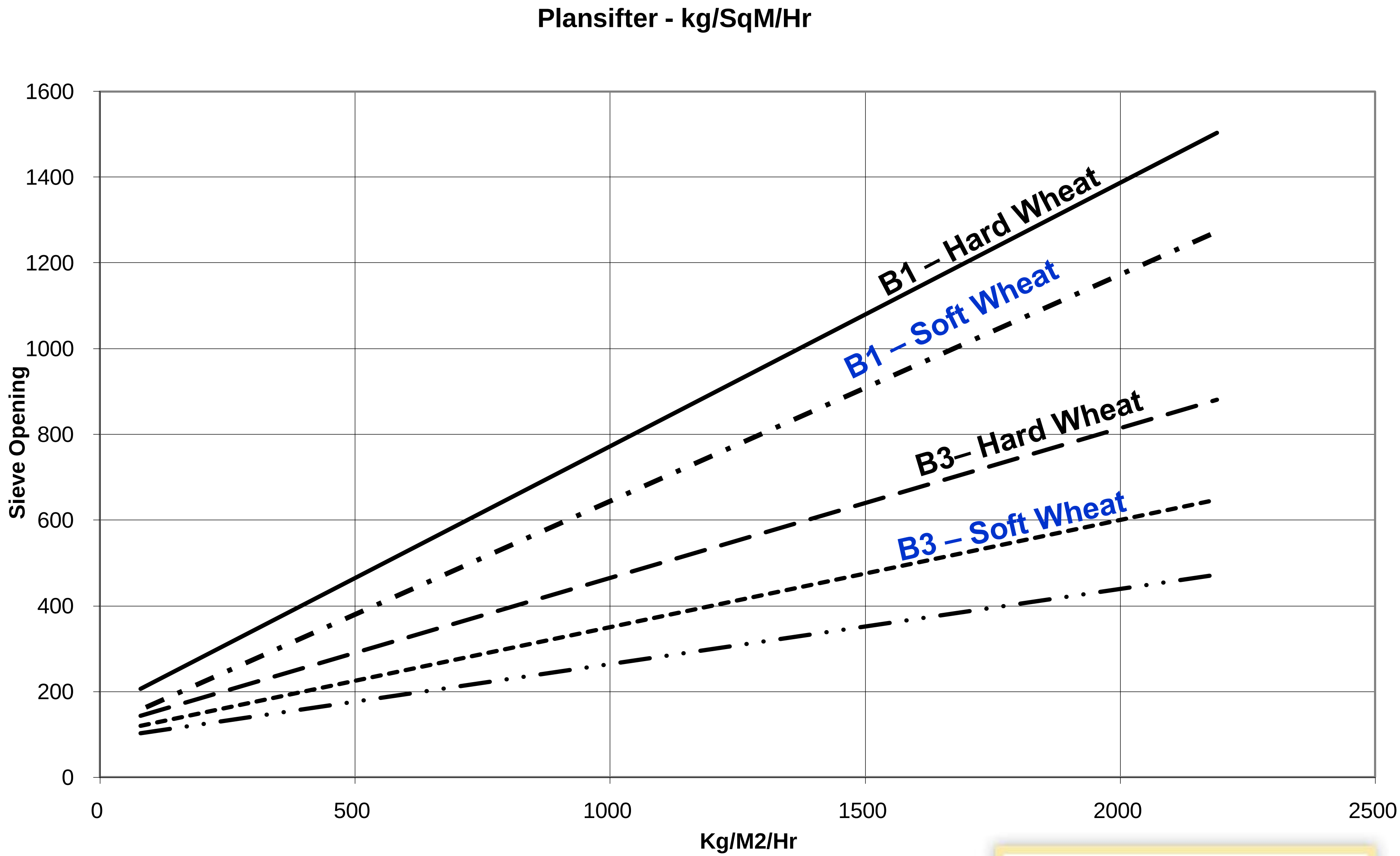


Soft wheat does not sift as easily

- 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.

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

Throughput examples



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

Sifting Characteristics of Soft and Hard Wheat Flour – D V Neel & R C Hoseny – Cereal Chemistry 61-4 259-261

Whitby 1958

TABLE I

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

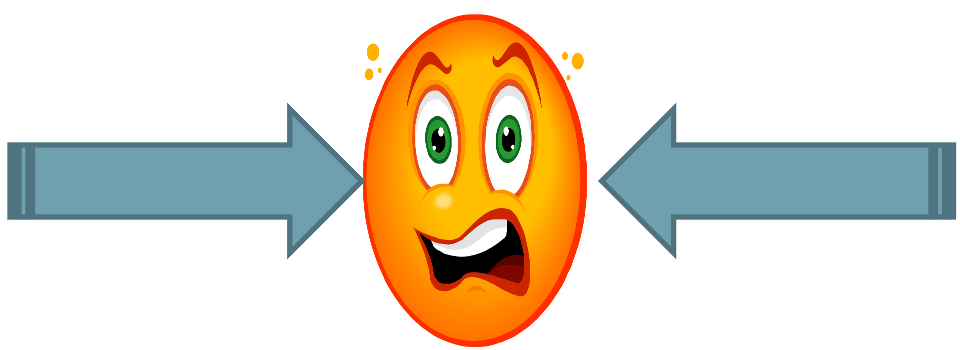
Time (sec)	Hard Wheat: Percent Through Sieve	Hard Wheat: Standard Deviation	Soft Wheat: Percent Through Sieve	Soft Wheat: Standard Deviation
5	7.3	1.8	4.1	0.77
10	13.0	3.8	73	1.4
20	24.5	6.0	12.5	2.4
30	34.3	8.1	17.2	3.6
40	44.8	10.9	21.8	9.3
50	53.3	12.7	26.2	5.0
60	61.3	13.8	30.0	5.7
70	67.5	14.4	33.9	6.2
100	70.5	14.3	39.9	7.3

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.



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

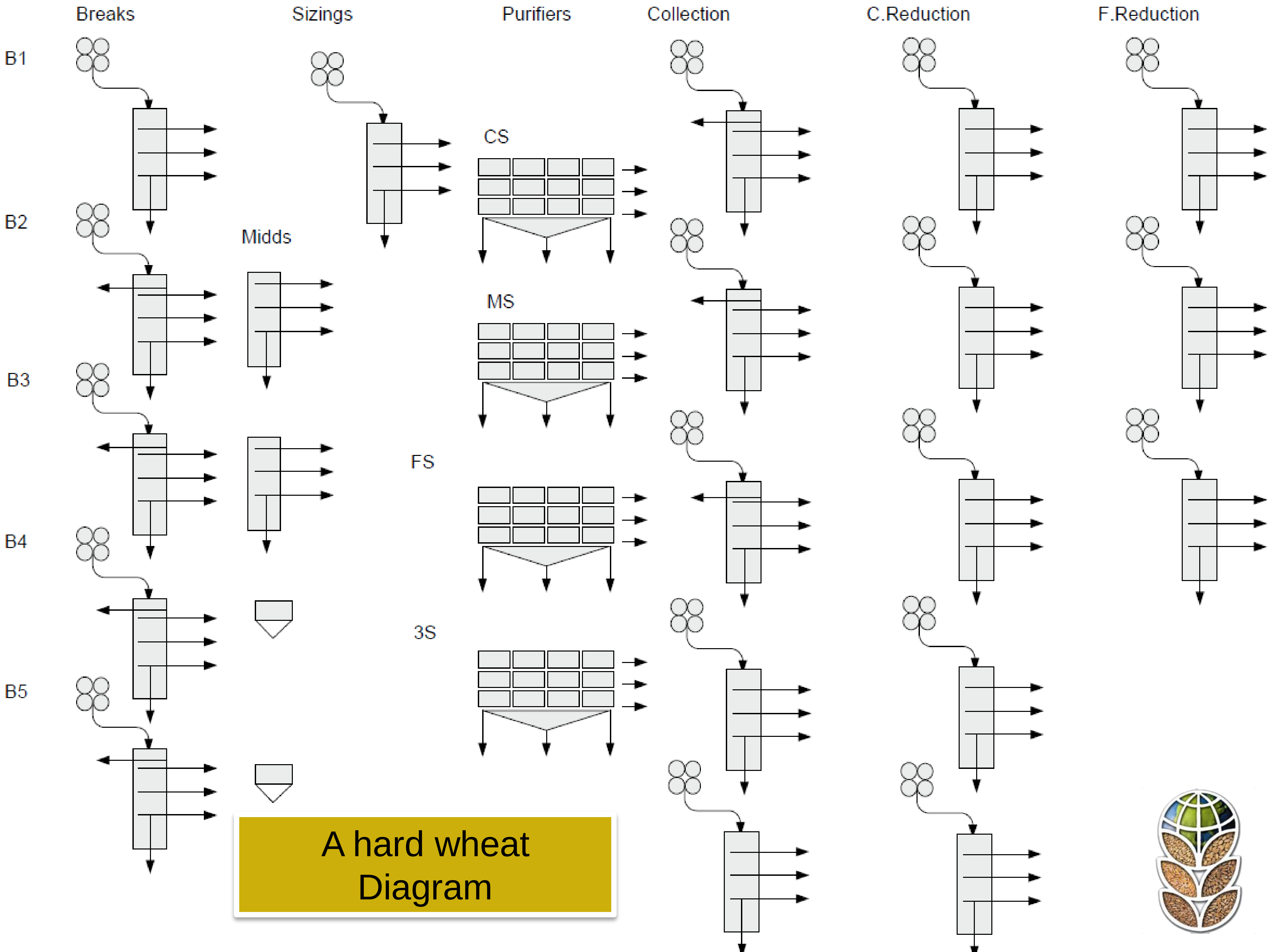
Determination of Roll horsepower:

$$Pt(Kw) = \left[(QxK) \times K1 \times K2 \times K3 \times K4\right] + Pv$$

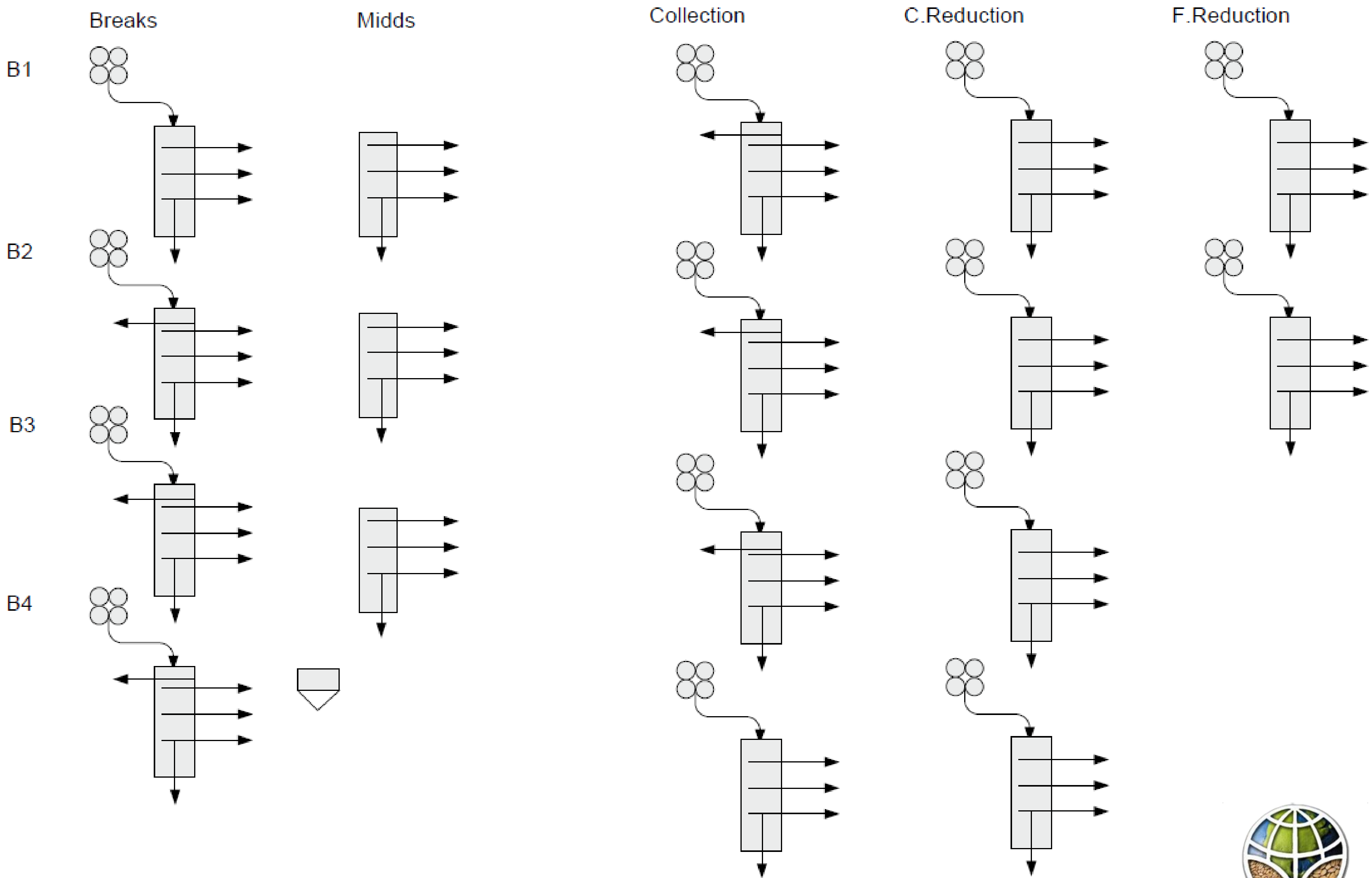
Symbol	Definition
Pt	Roll power in Kilowatts (consumed)
Q	Stock quantity in Kg/min
K	Grinding power coefficient for passage
K1	Coefficient for power factor and mechanical losses
K2	Wheat hardness coefficient
K3	Ambient temperature coefficient
K4	Location Altitude coefficient
Pv	Rollermill power – no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

Values of coefficient K2 = 1.00 on soft wheat, 1.03 on hard wheat and 1.08 on durum wheat.

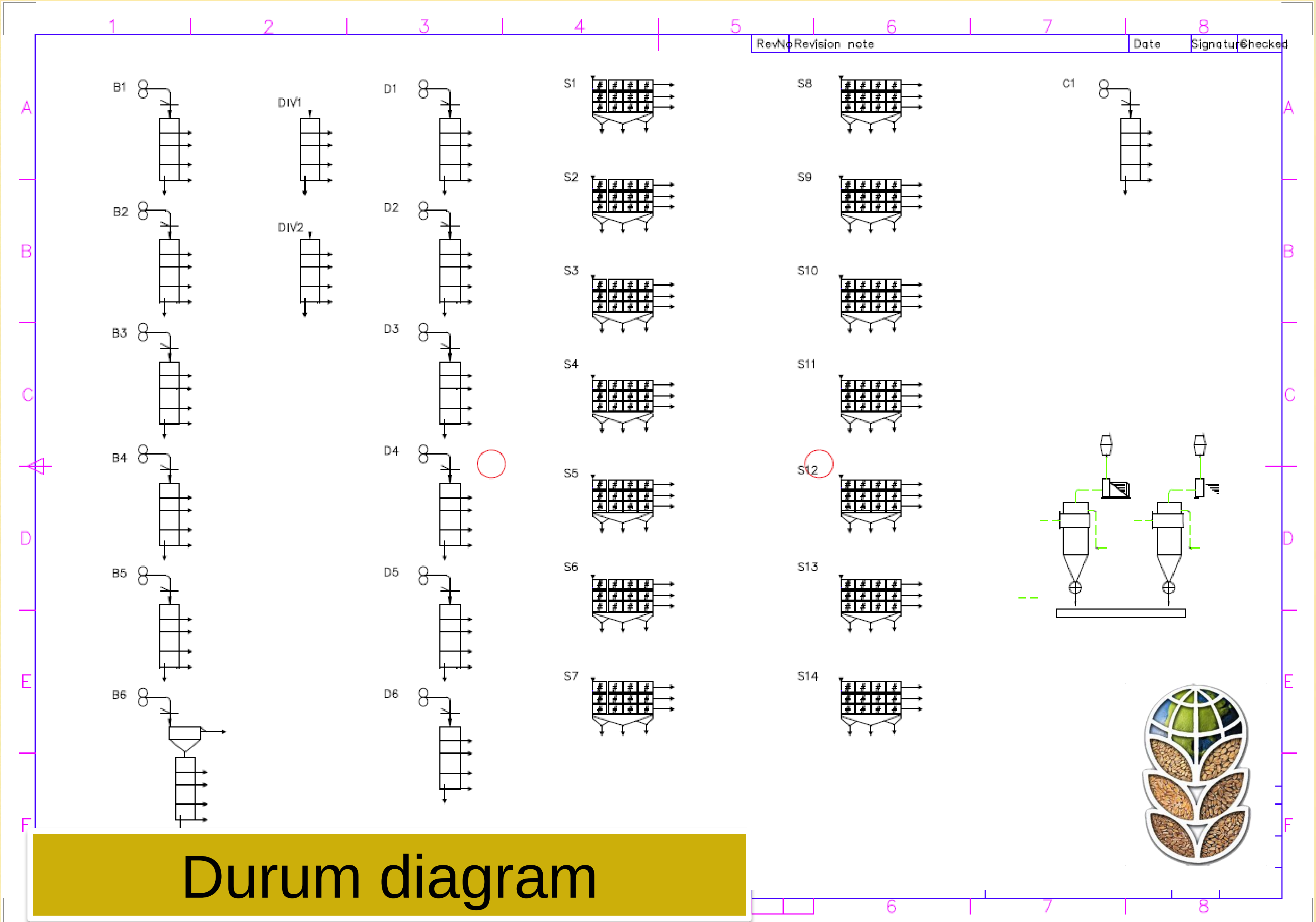
ASSOCIATES
The world's most reliable choice.



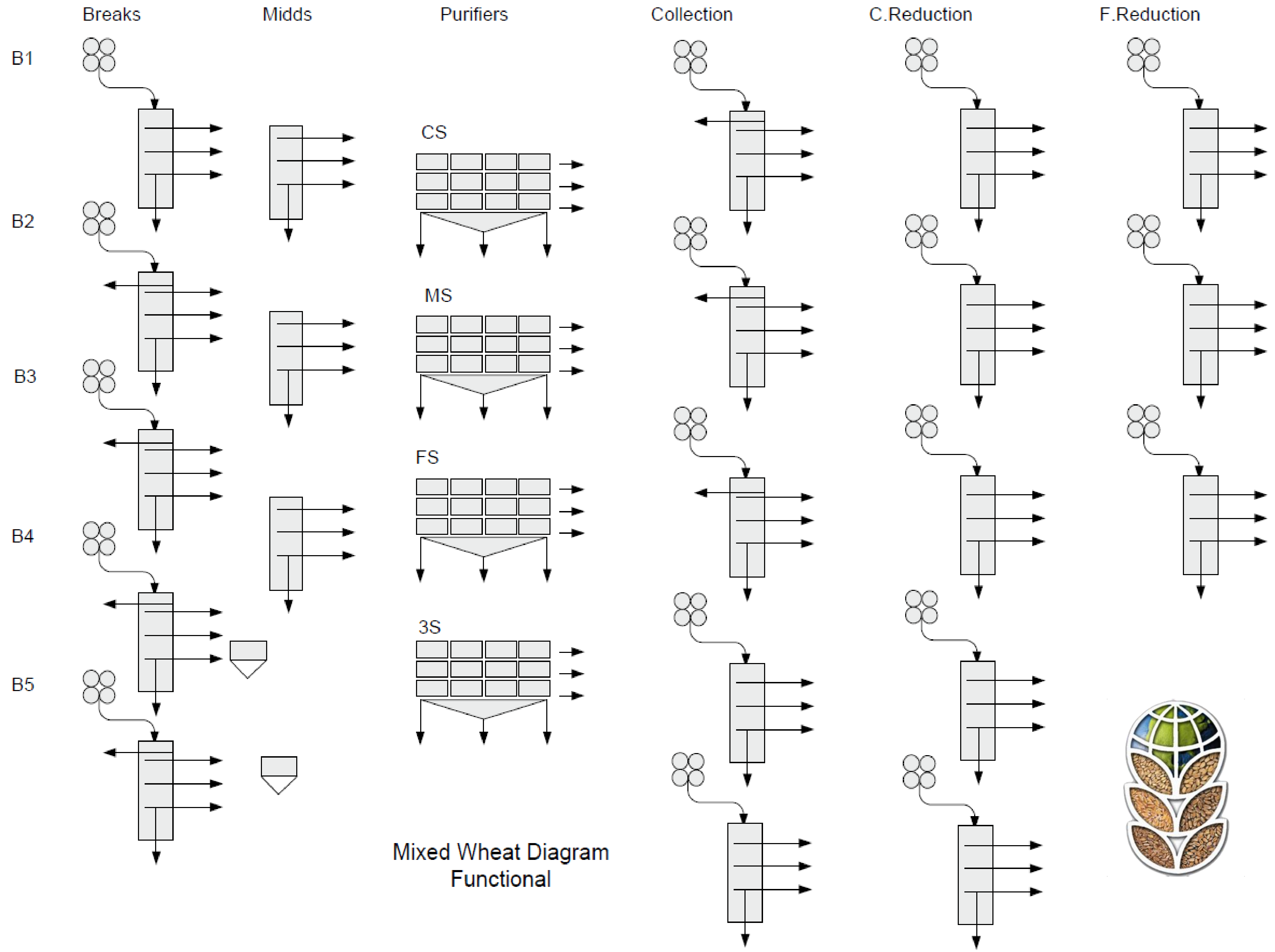
A hard wheat Diagram



A soft wheat diagram



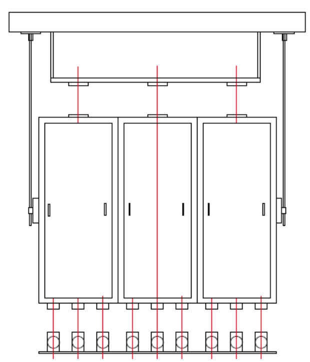
Durum diagram

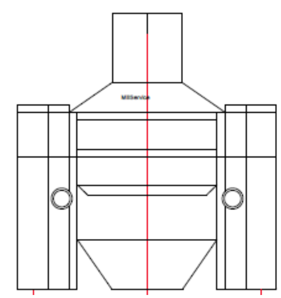


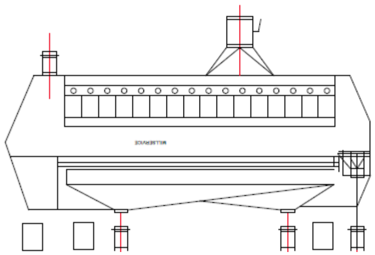
Mixed Wheat Diagram
Functional

GRIST	SPECIFIC SIFTER AREA M^2 / 100KG	ROLLERMILL LENGTH MM/100KG	PURIFIER SURFACE MM/100KG
Soft Wheat	0.065	10-11	None
Hard Wheat	0.055	12-13	6-6.5
Mixed Diagram	0.065	12-13	6-6.5

European specs.







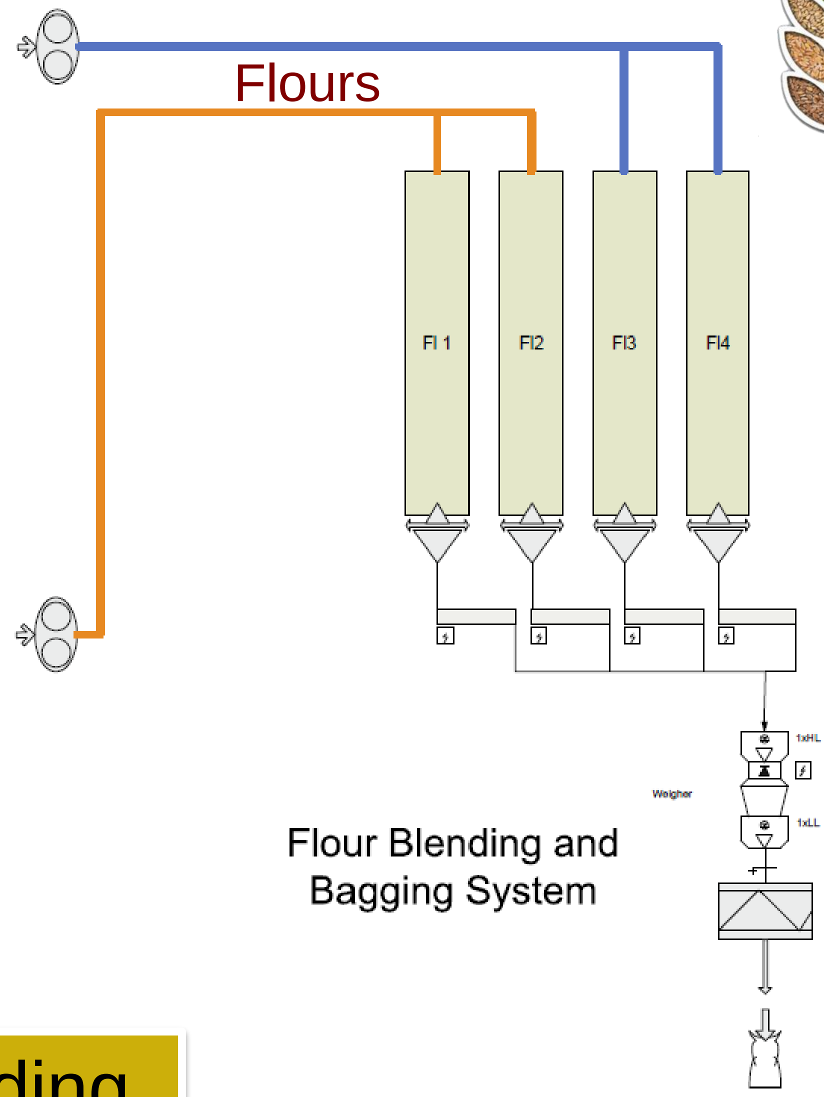
The Solution – flour blending.

Optimal cleaning & tempering
Optimal diagram

Medium to Hard Wheat Milling Line

Optimal cleaning & tempering
Optimal diagram

Medium to Soft Wheat Milling Line



Blended Flours

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