INTERNATIONAL ASSOCIATION OF OPERATIVE MILLERS

CHOPIN TECHNOLOGIES

LabMill

Laboratory Milling to Predict Wheat Behavior at Plant Level

Arnaud Dubat

Business development Director

KPM ANALYTICS

25/10/2016

Presentation Map

LabMill Presentation

Precision of the LabMill

Simplifying the data reading

Comparison with industrial mill

Blending wheat with the LabMill

LABMILL

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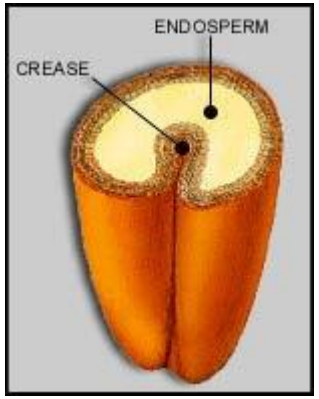
LABMILL

Milling: a science made of several steps!



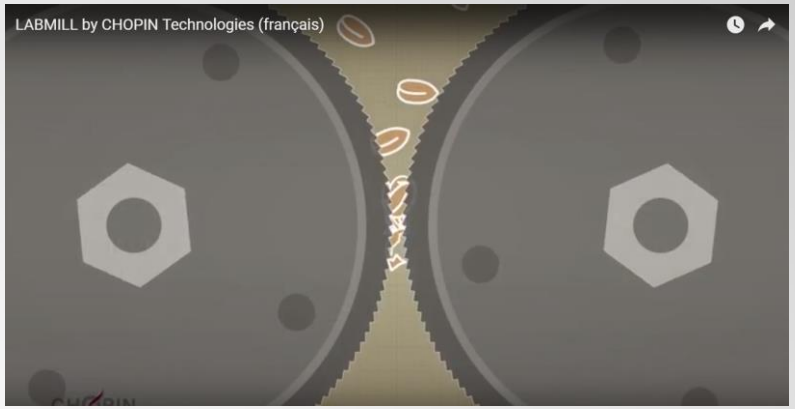
Wheat kernel

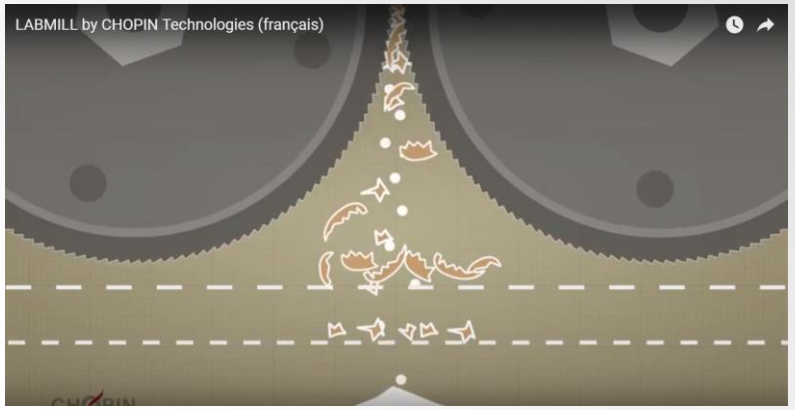
- Wheat kernel is not a rice kernel : because of the **crease**!
  - To remove the bran and obtain white flour, the miller needs **to act progressively**.

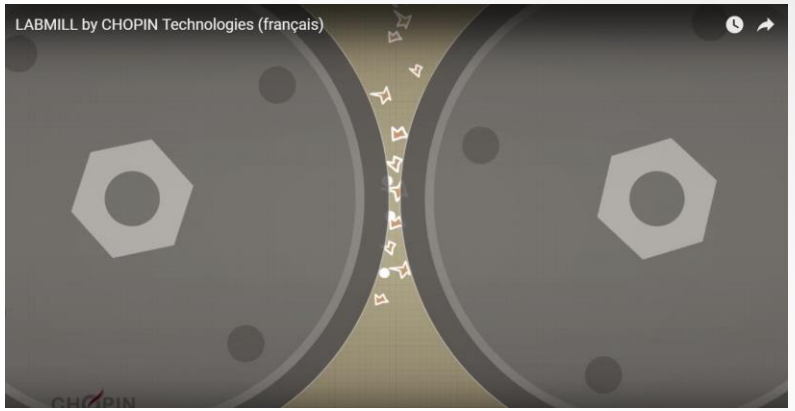
  - **First step = breaking ("opening" the grain)**
  - **Grooved/corrugated rolls**

  - **Second step = reduction (avoiding breaking bran particles)**
  - **Smooth rolls**

- **There are no mills in the world that are not using smooth rolls (common soft/hard wheat).**



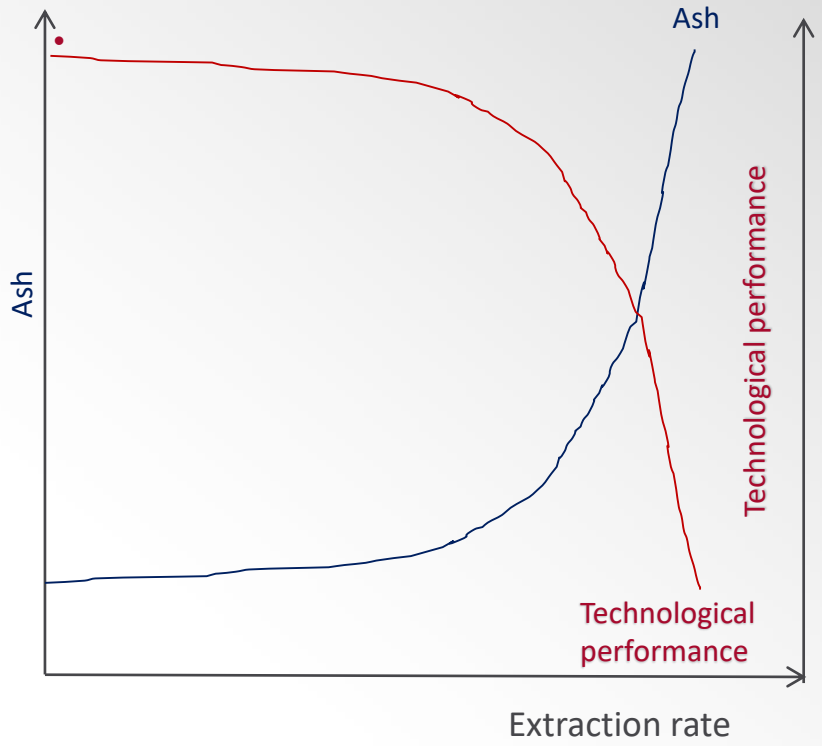




Wheat Milling economics

How much could you save?

- Mill 400 tons (wheat) / day
- Flour price : 0.62 €/kg
- Bran price : 0.25 €/kg
- Total yield : 98%
- Average flour yield : 78%



- **1%** flour extraction extra means:

+1476 €/day

+500 000 €/year

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What is the goal of a laboratory mill?

- In the milling industry, wheat is **characterized by its milling behavior** (resistance to crushing and extraction rate) and by the **quality of the flour produced**.

- LabMill is designed to **anticipate**, in the laboratory, the behavior of wheat in the industrial mill, and to evaluate its **extraction potential** and the **quality of the flour produced**.

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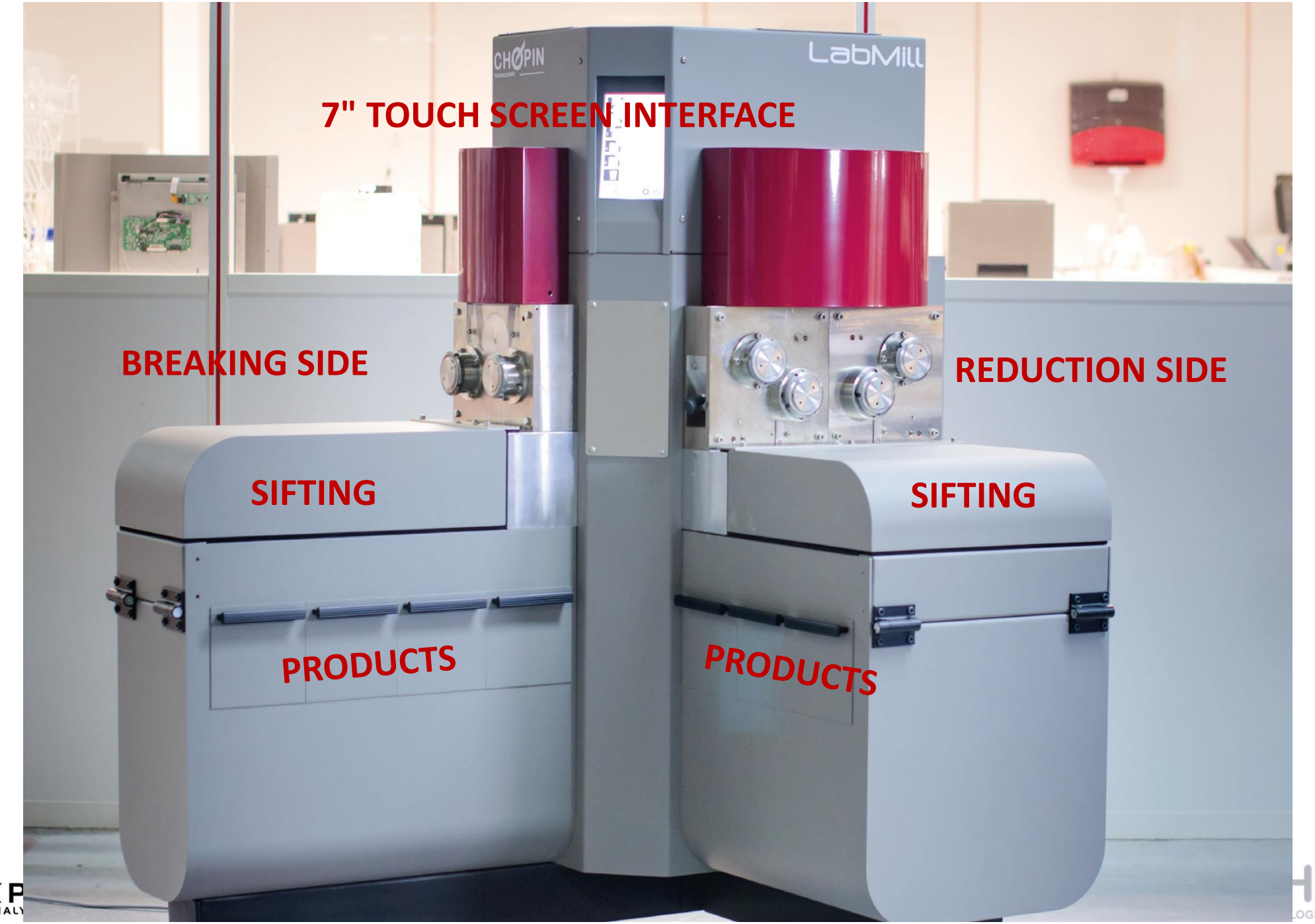
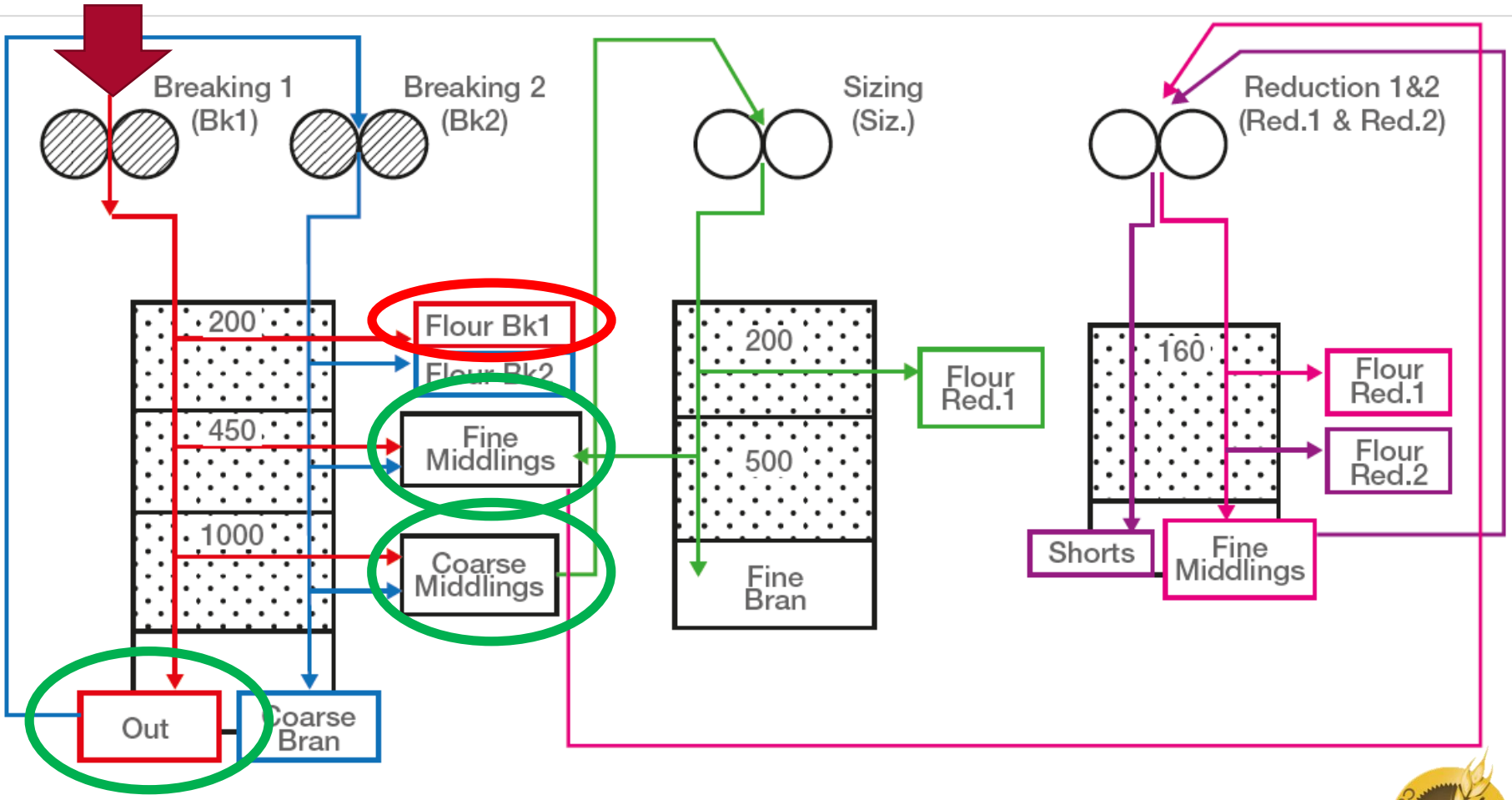

CHOPIN
LabMill
7" TOUCH SCREEN INTERFACE
BREAKING SIDE
REDUCTION SIDE
SIFTING
SIFTING
PRODUCTS
PRODUCTS

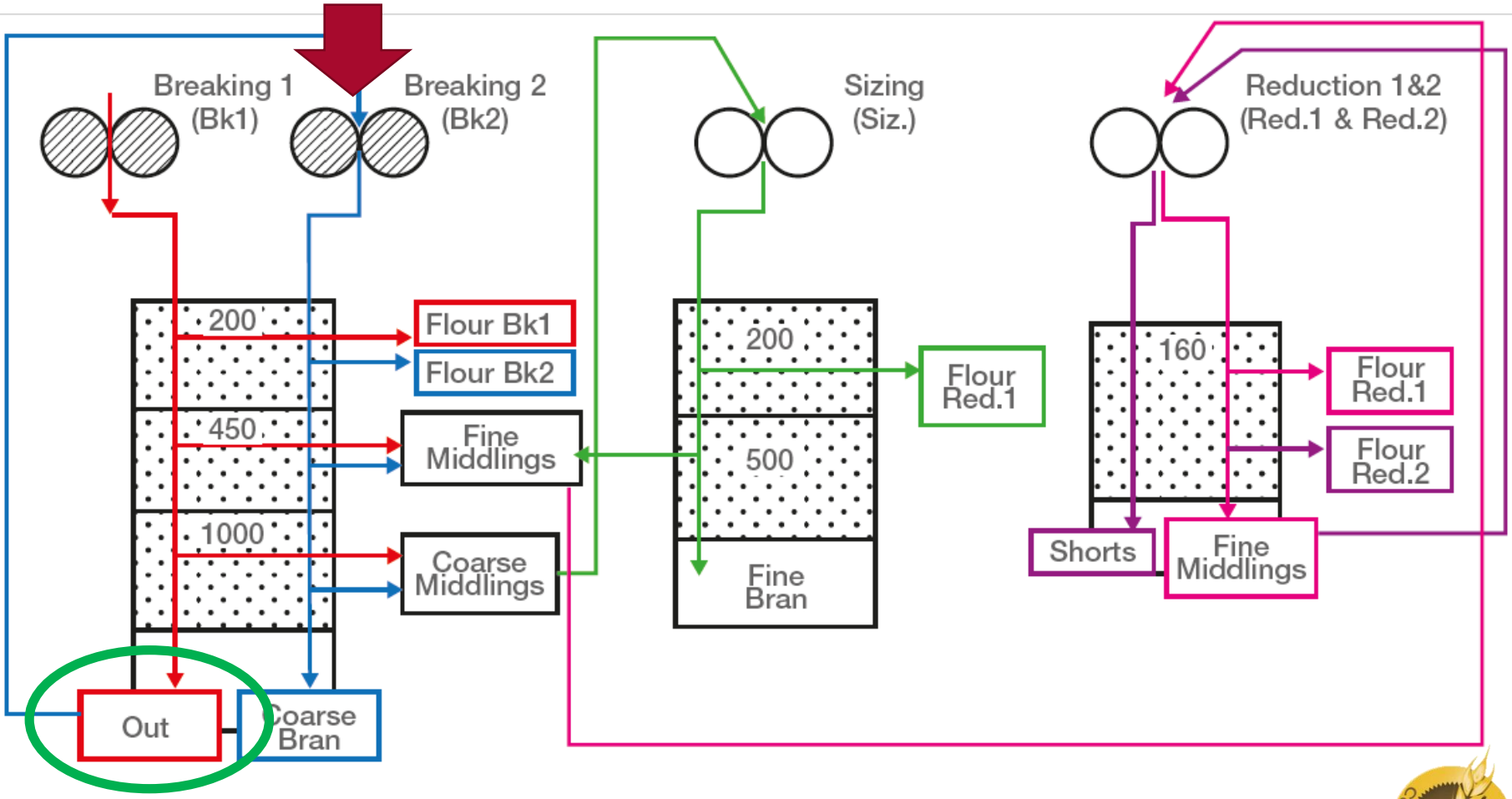
A patented* milling diagram



LabMill was developed within the Milling Performance Consortium (AFSA, Arvalis-institut du végétal, ANMF, Danone Vitapole, INRA, IRTAC, Ulice, CHOPIN Technologies).

Patent FR N° 0905572 | US N°9 067 210

A patented* milling diagram



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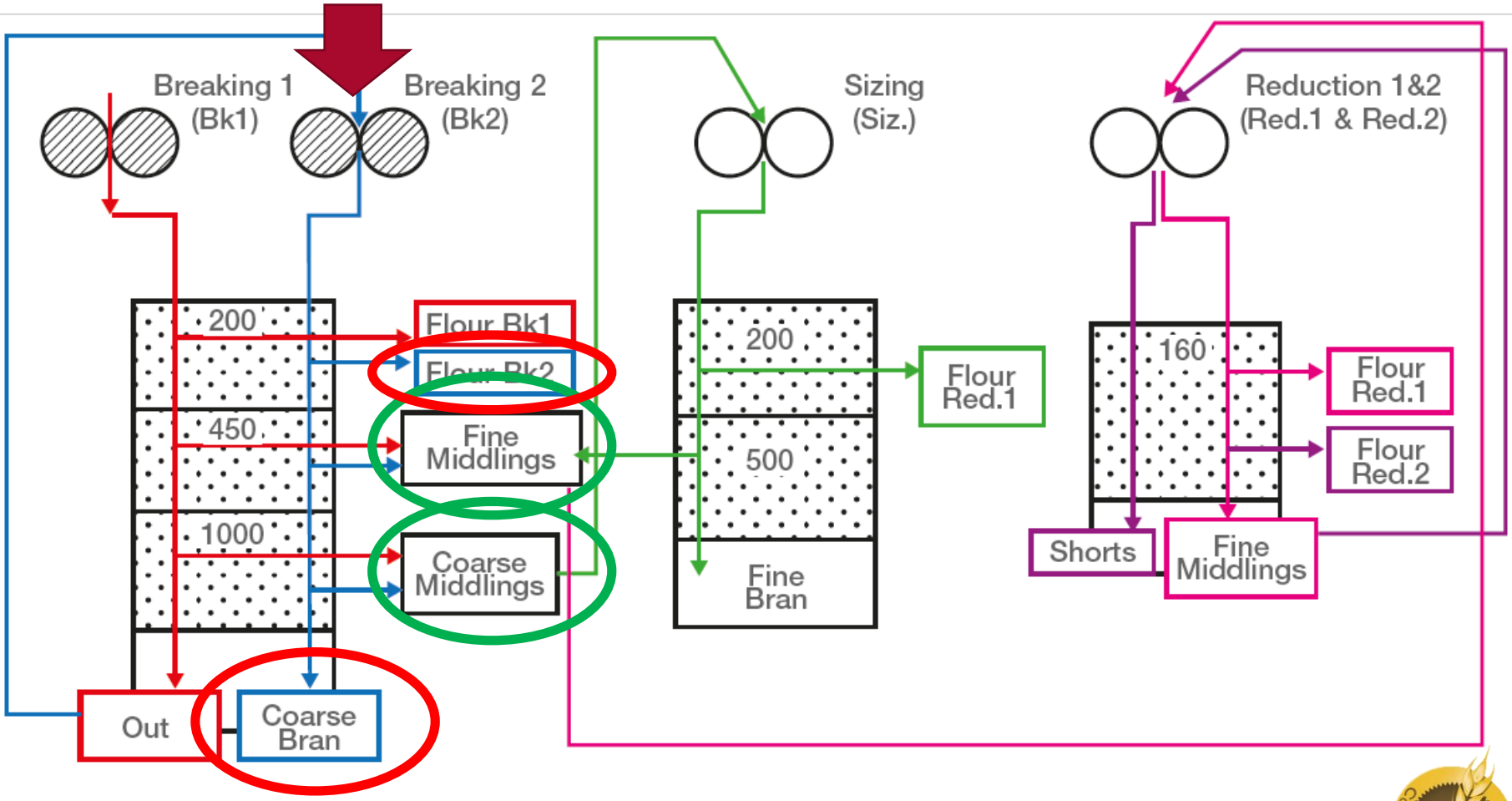

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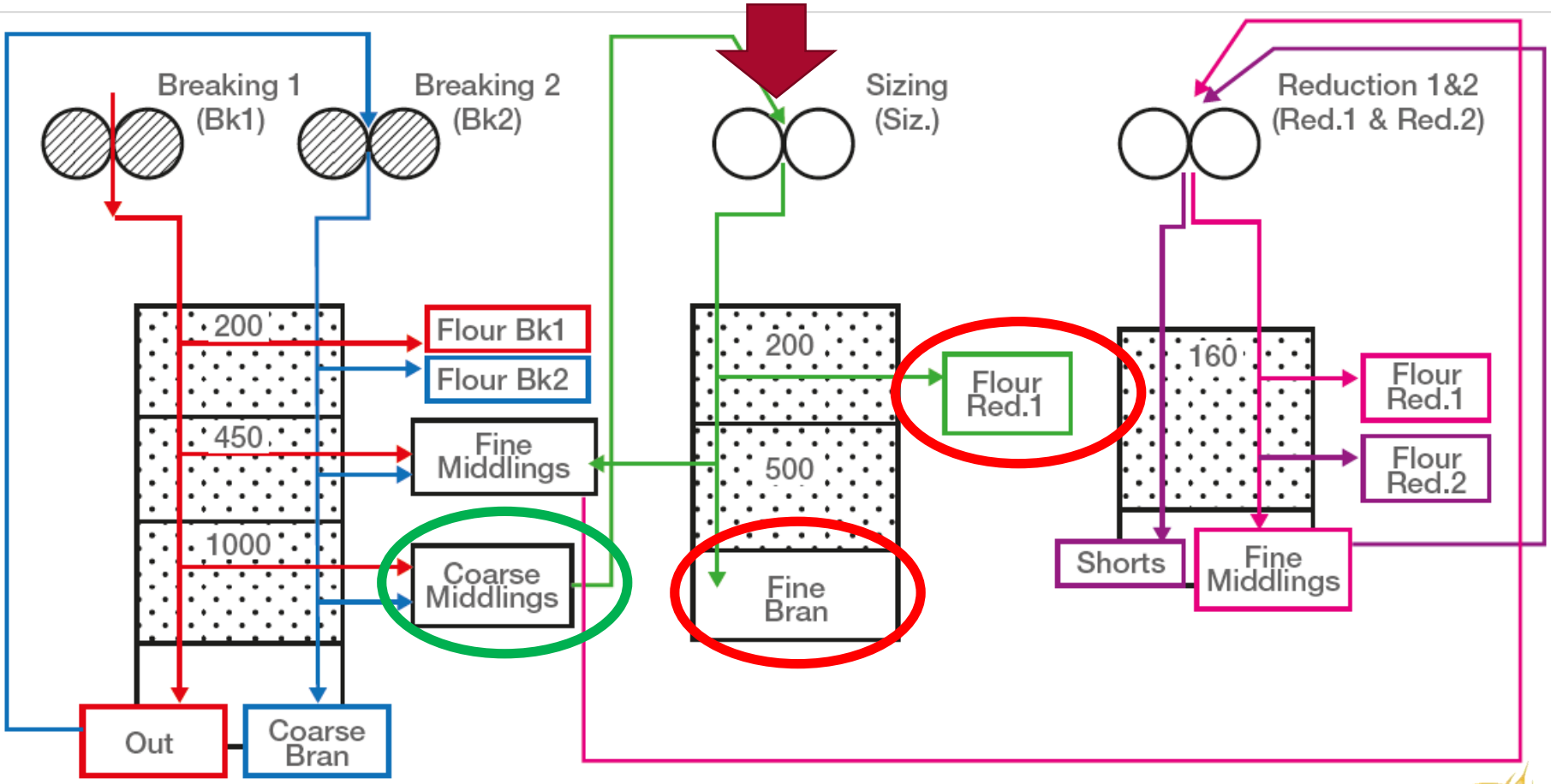

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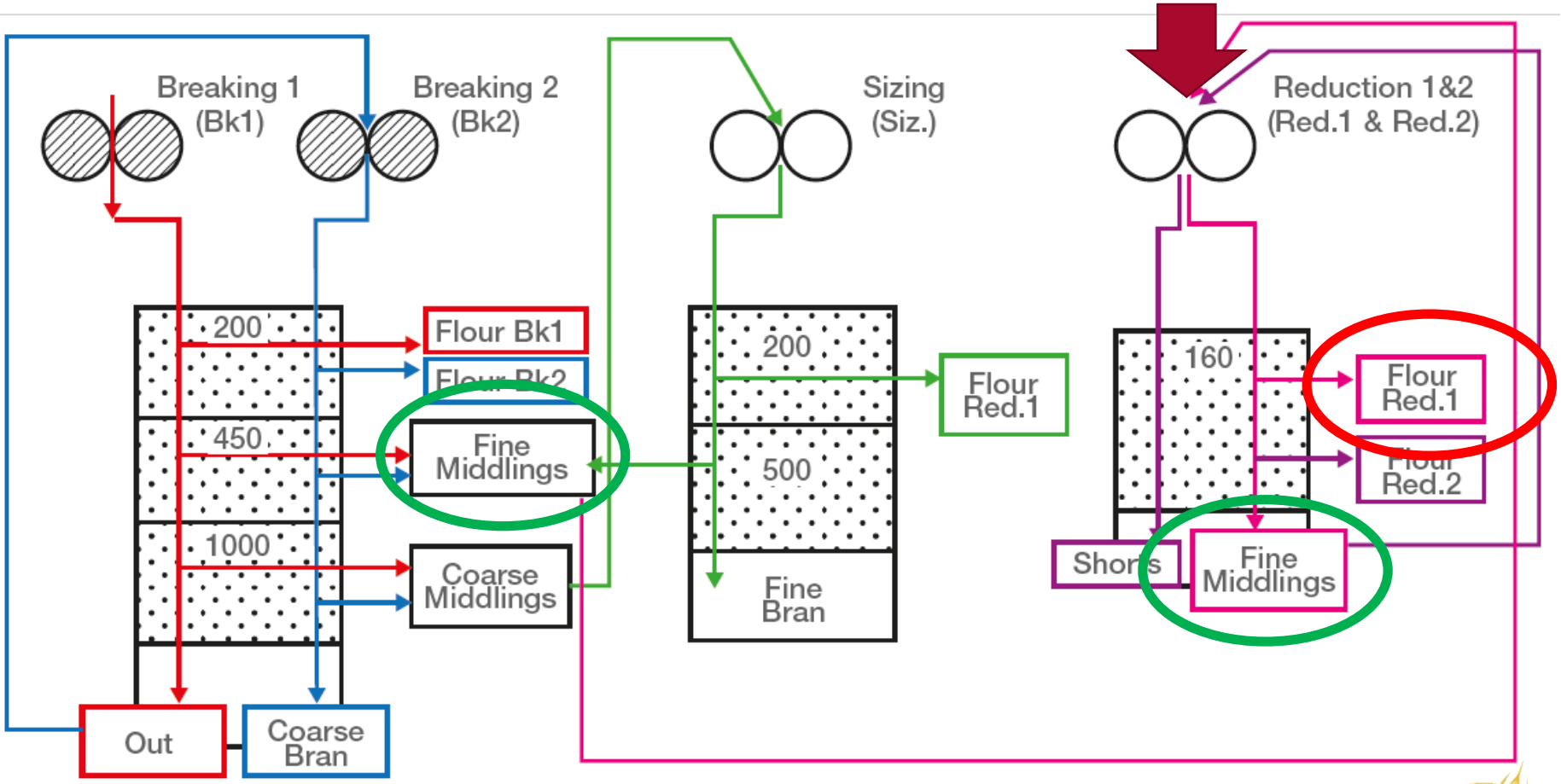

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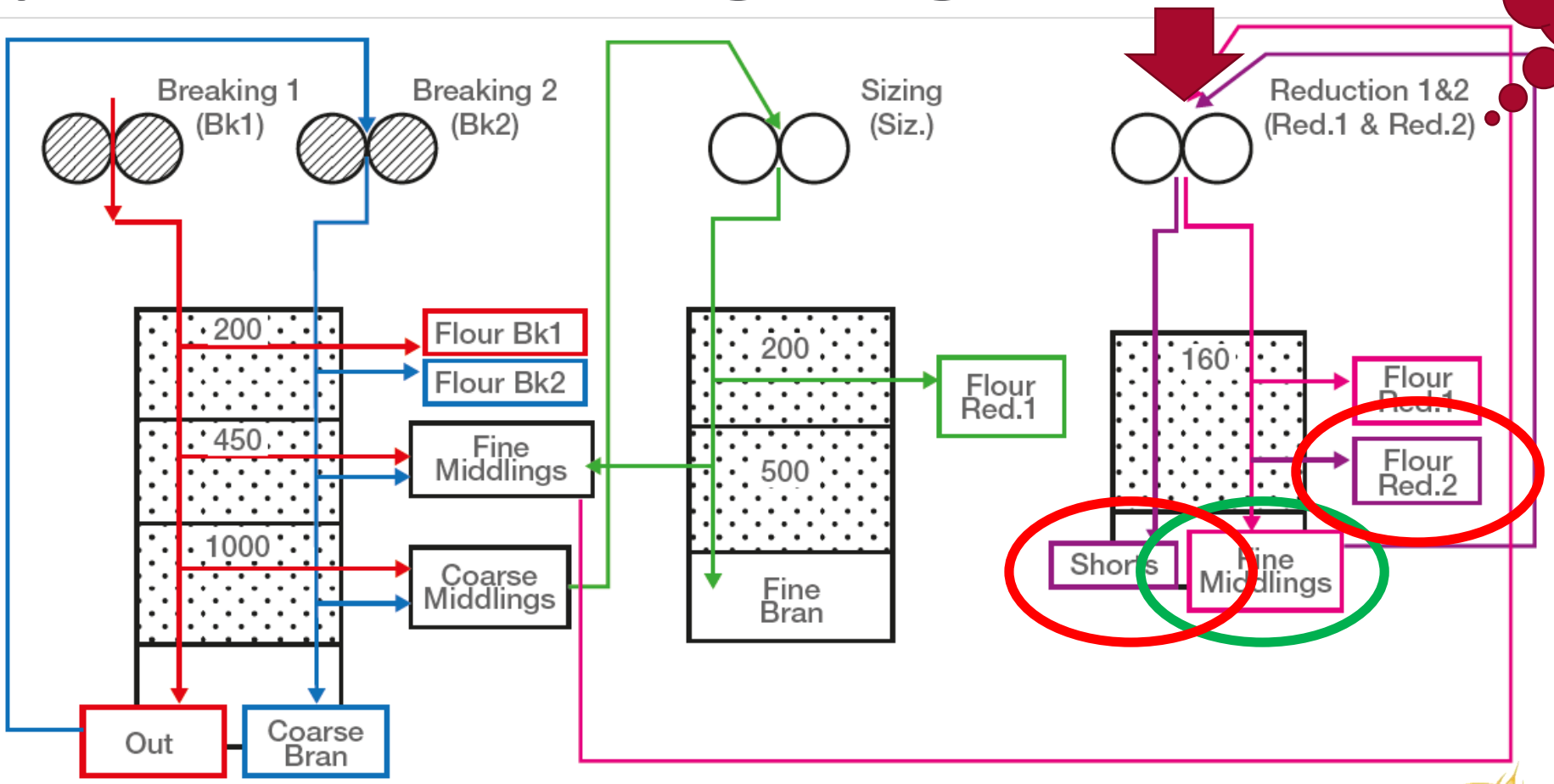
3 reductions are better



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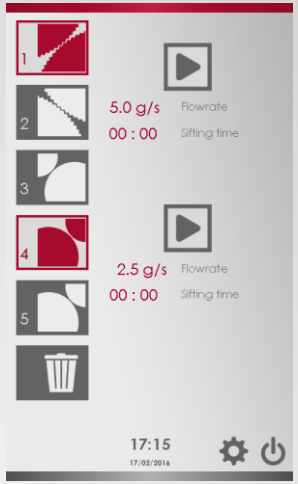
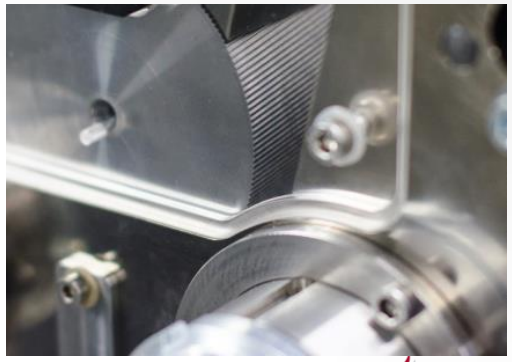
LabMill - Key features

- Modern and **user-friendly interface** (7" touch screen)
- Very **precise and adjustable feed system**
  - Feeding hoppers equipped with a **precision scale**
  - Provides a **constant flow of grain**, adapted to every type of wheat
- **Individually adjustable cylinders**
  - Adjust settings to mimic industrial milling
- **Centrifuge sifting**
  - Compact, economic and easy maintenance
  - Easy to change sieves
  - Time of sifting adjustable
- **Non automatic mill**
  - Because millers want to see the different products





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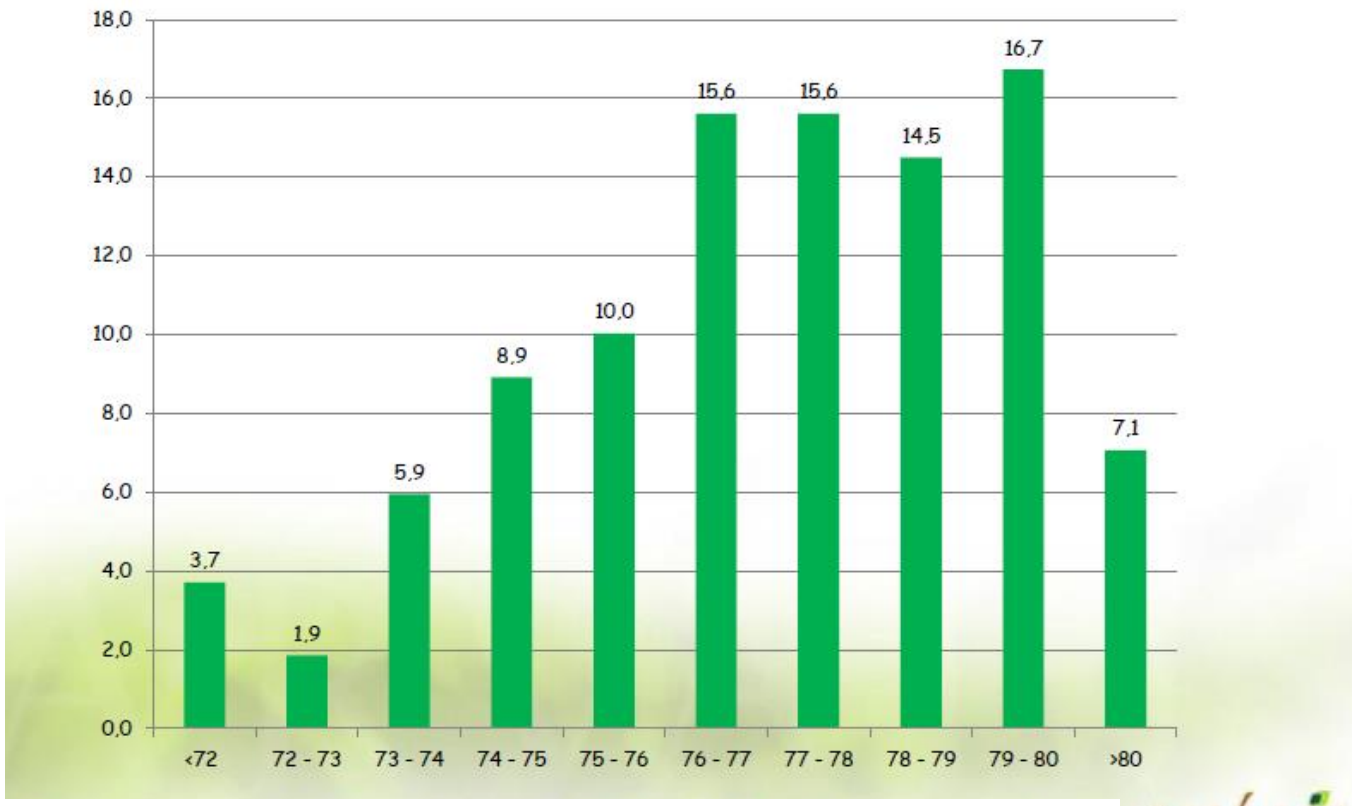
LabMill provides high extraction rates…



Milling Quality Consortium – April 2012

ARVALIS Institut du végétal

- Range: **66.2%** to **81.5%**
- Average hard wheat: **77%**
- Average soft wheat: **75%**

- *Note: samples tempered to 16.5% moisture content for 24 hours*

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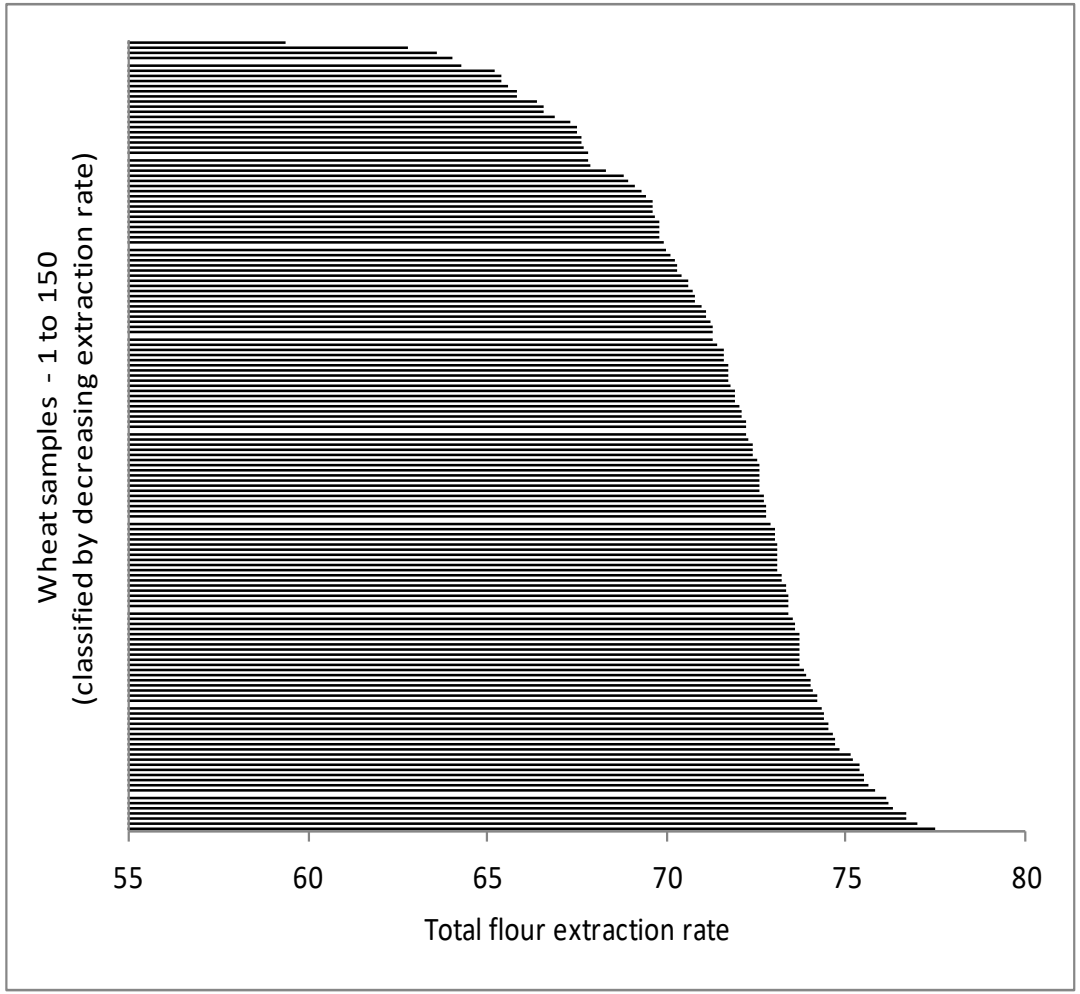
LabMill shows the great differences on wheat behavior during milling

- **150 wheat samples**, coming from **14 countries** distributed on the **5 continents**
- LabMill with the **same protocol** -> change behavior and results if we adjust the LabMill
- **Flour production is highly variable** from one sample to other.
- Not only the **global quantity of flour varies** (extraction rate changes from 59.4% to 77.5%)



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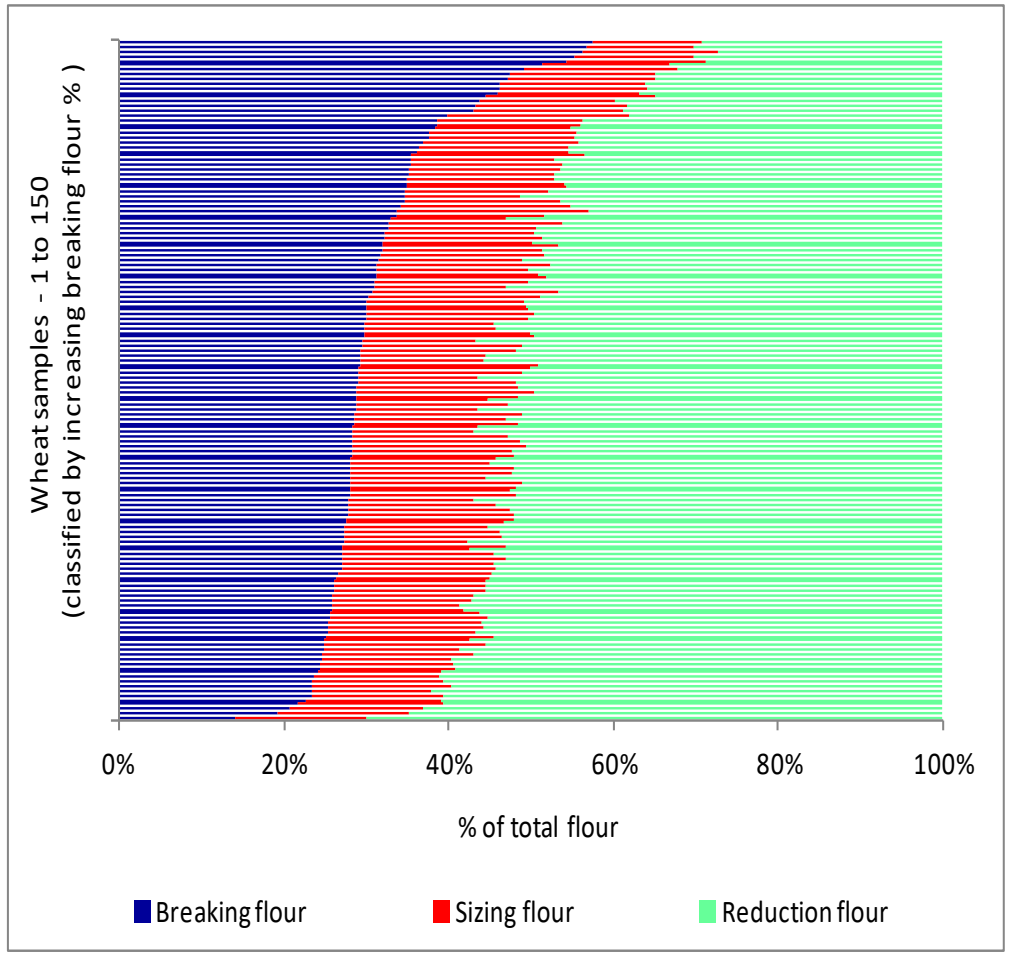
CHOPIN TECHNOLOGIES

LabMill shows the great differences on wheat behavior during milling

But also the **distribution among the different milling steps :**

- **breaking** step produces between 14% and 58% of the total flour
- **sizing** step between 13% and 23%
- **reduction** step between 27% and 70%



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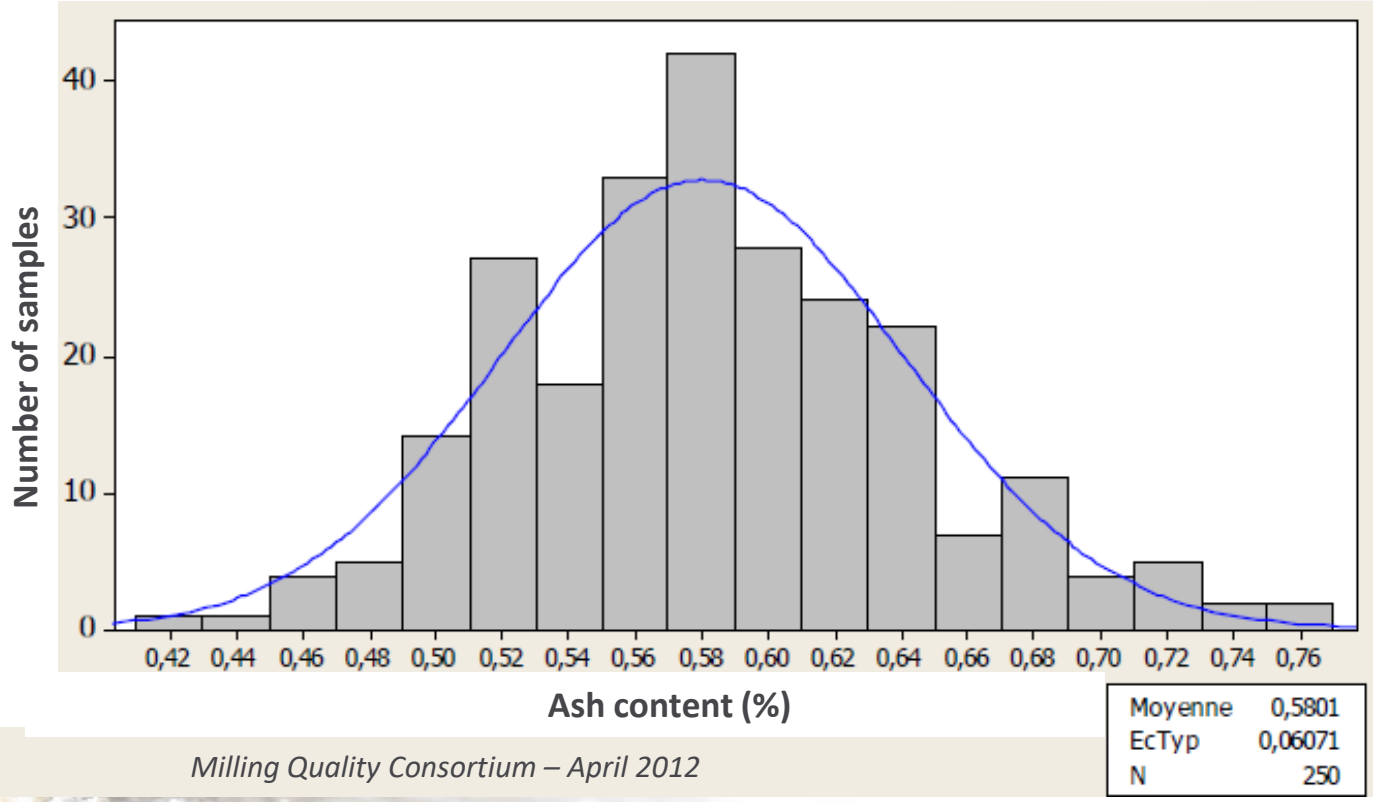
…and low ash and damaged starch contents!



Milling Quality Consortium – April 2012

- Range: **0.42%** to **0.76%**
- Average : **0.58%**

This corresponds to :

French : Type 55

American : All purpose & bread

Argentinian : "000"

German : 550

Variety	SOISSONS	PAKITO	APACHE	ARKEOS1	ARKEOS2	CAPHORN	CALCIO	CROUSTY	MATHEO
Ash (%)	0.57	0.55	0.56	0.45	0.5	0.62	0.59	0.51	0.66
Damaged starch (UCD)	**16.63**	**15.38**	**13.53**	**6.77**	**10.03**	**20.28**	**15.52**	**7.75**	**14.8**

Milling Quality Consortium – November 4, 2015

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Presentation Map

LabMill Presentation

Precision of the LabMill

Simplifying the data reading

Comparison with industrial mill

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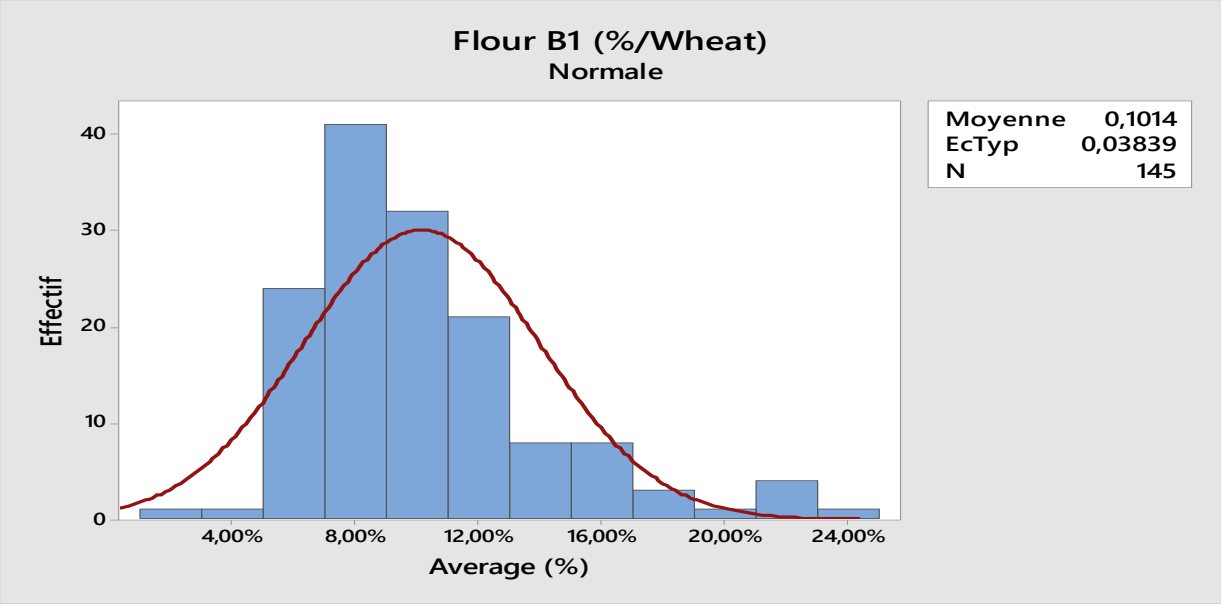
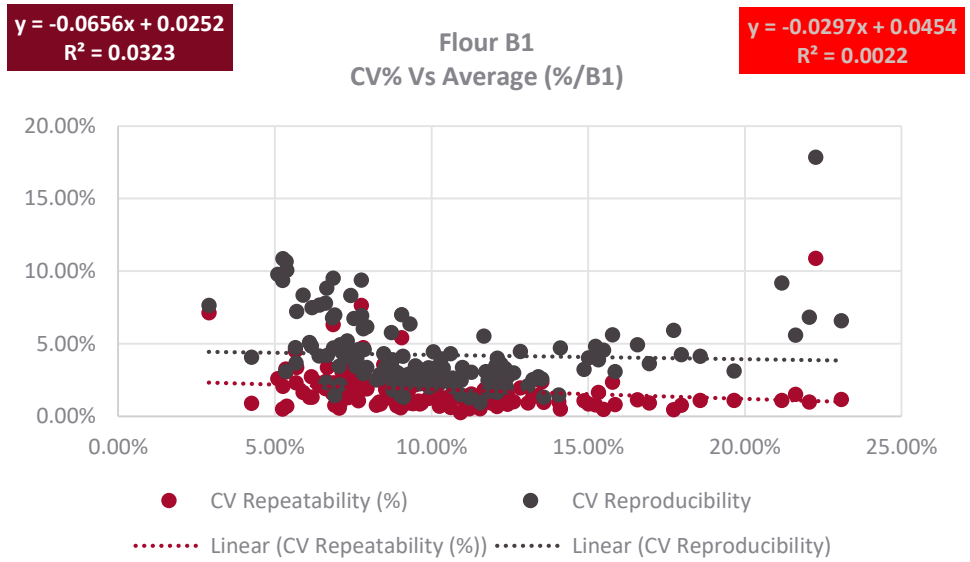
LABMILL

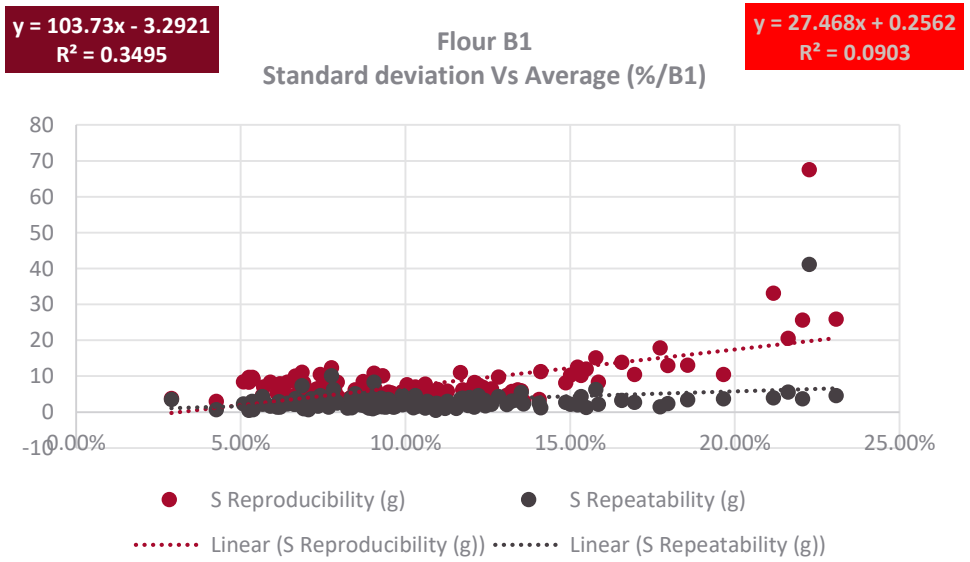
Experimental setup

- 150 wheats from soft to hard originating from 17 countries.
- 2 LabMill (A & B)
- 3 analysts
- Observation period 4 month (April-August 2016)
- Each sample (1700g) was tested 5 times on each mill.
  - Repeatability is measured as the average standard deviation of the 5 subsamples tested on the 2 mills $(Sr_{LabmillA} + Sr_{LabmillB})/2$
  - Reproducibility is measured as the standard deviation of the 10 subsamples tested on the 2 mills (A and B)

Example:1st Break Flour







Our observations cover a wide range of B1 flour [3%-25%)
In this range repeatability and reproducibility remain constants

	Average CVr(%)**	Average CVR(%)**
Extraction rate	1,9%	4,2%

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October 8, 2018

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Summary

Parameter	Range (%)	Average	Repeatability CV% Calculated on the mass of product (in g)	Reproduciblity CV% Calculated on the mass of product (in g)
Extraction rate	56-76	70,3%	1,2%	1,7%
1st Break Flour	3-25	10,1%	1,9%	4,2%
2nd Break Flour	6-16	11,2%	1,4%	4,0%
Sizing Flour	8,5-18,5	12,8%	2,3%	4,2%
1st Reduction flour	8-35	24,5%	4,7%	6,6%
2nd Reduction flour	5-14	7,8%	7,8%	10,7%
3rd Reduction flour	3-7	3,2%	10,8%	13,4%
Coarse Bran	8-24	14,4%	3,3%	6,1%
Fine Bran	4-12	6,5%	2,7%	8,2%
Shorts	3-18	7,8%	6,3%	12,2%

Conclusions

- This first approach shows
  - A very good repeatability, higher CVs are related to streams with relatively little amount of product, then a minimum difference in weight has higher impact on CVs.
  - Reproducibility is also good taking into account the large variability of test conditions.
  - Last but not least the LabMill shows to perform exactly the same on all kind of wheat making it a mill suitable whatever the wheat hardness is.

Presentation Map

LabMill Presentation

Precision of the LabMill

Simplifying the data reading

Comparison with industrial mill

Blending wheat with the LabMill

LABMILL

Origin of the idea

- 150 wheat, submitted to the same milling, have shown extremely diverse behaviors.
- Based on these observations, could we develop a way to easily characterize wheat behavior during milling?
- What could be the benefit of such measurement?

Resistance and dissociation Indexes

- Based on these observations we can characterize wheat behavior during milling with a simple Resistance to Crushing and Dissociation Indexes

Resistant To Crushing

$$\frac{W_{Fine\ MiddlingsB1} + W_{FlourB1}}{W_{Coarse\ MiddlingsB1} + W_{MealB1}}$$

B1 Index	B1 RCi
<16%	7
16,1-21%	6
21,1-26%	5
26,1-31%	4
31,1-36%	3
36,1-41%	2
>41%	1

Easy To Crush

From B1 | From B1+B2

4 5

Resistance Index

Dissociation index

$$\frac{\sum \ Break\ Fine\ Middlings}{\sum \ Break\ Coarse\ Middlings}$$

B2 RCi	B2 Index
7	<106%
6	106,1-113%
5	113,1-122%
4	122,1-131%
3	131,1-148%
2	148,1-157%
1	>157%

Hard to dissociate

Easy To Dissociate

The Reduction index

$$\frac{\sum \quad Reduction\ flour}{\sum \quad Reduction\ Middlings}$$

From
Red1+Red2+Red3

5

Reduction index

Red RCi	Red Index
7	<70%
6	70,1-75%
5	75,1-79%
4	79,1-86%
3	86,1-92%
2	92,1-97%
1	>97,1%

Hard to dissociate

Easy
To Dissociate

Milling Performance Index (MPi), describes the wheat behavior during milling.

4	5	5

Resistance Index
(easiness to open the kernel)

Dissociation index
(easiness to produce fine middlings)

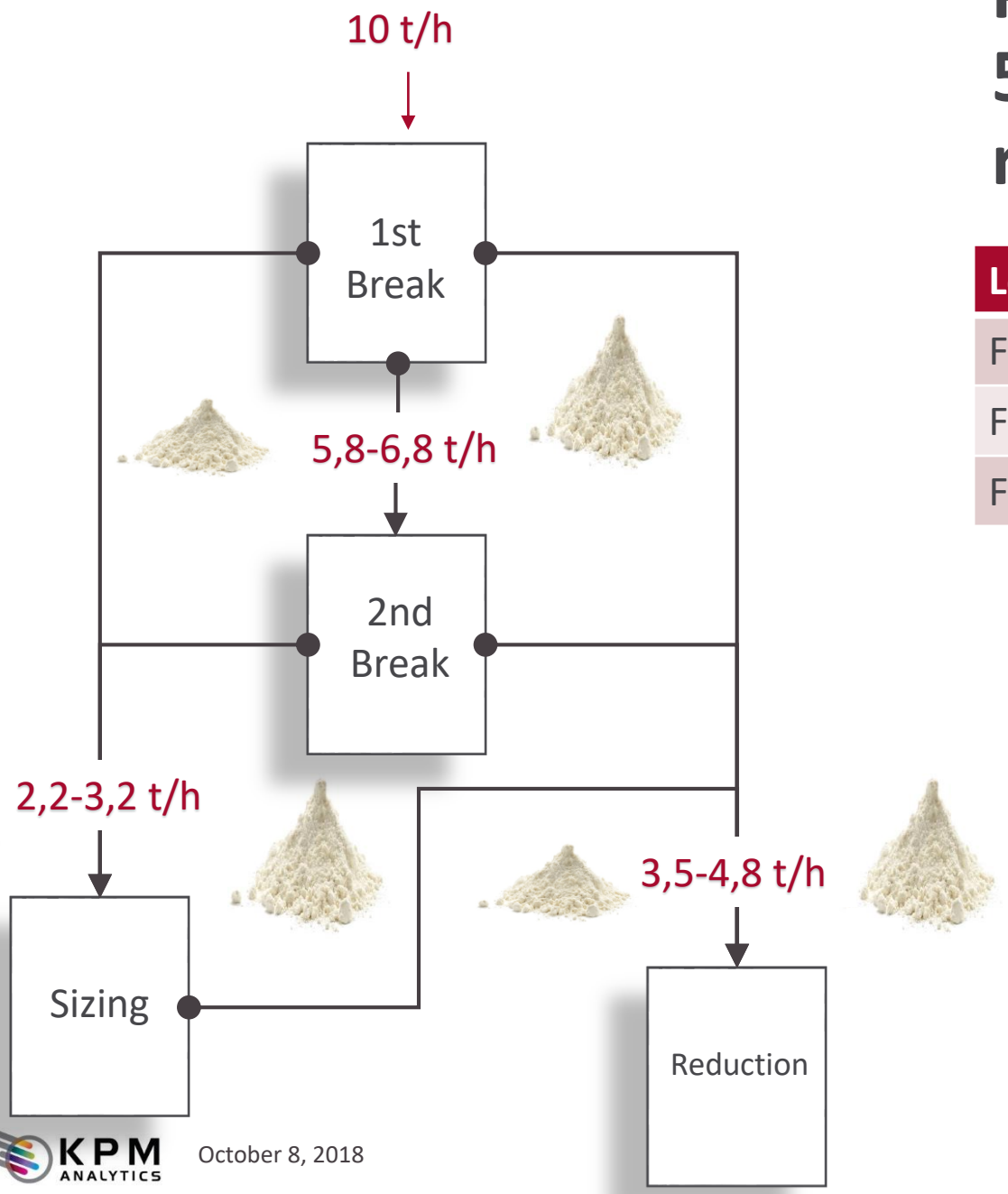
Reduction index
(easiness to extract flour from fine middlings)

Practical example 1
5 samples with same Extraction rate and different MPi

MPi	Extraction rate (%)	Meal/B1 (%)	Large Middlings B1 (%)	Fine Middlings B1 (%)	Flour B1 (%)	Coarse Bran (%)	Large Middlings/B2 (%)	Fine Middlings/B2 (%)	Flour B2 (%)	Fine Bran (%)	Fine Middlings/Sizing (%)	Flour Sizing (%)	Fine Middlings/Red1 (%)	Flour/Red1 (%)	Fine Middlings/Red2 (%)	Flour/Red2 (%)	Fine Middlings/Red3 (%)	Flour/Red3 (%)	Feed material → Sizing (%)	Feed Material → Reduction (%)
233	70,0	57,6	14,3	12,1	15,9	17,1	7,9	17,9	14,5	5,2	5,3	11,4	16,7	18,1	10,1	6,7	7,4	2,8	22,1	35,3
333	70,0	58,6	16,0	11,8	13,5	15,4	9,1	21,3	12,6	5,7	6,8	12,4	19,0	20,5	12,0	6,9	8,7	3,4	25,0	39,8
444	69,8	61,5	15,4	10,9	12,0	16,5	10,1	22,6	12,0	5,6	7,9	11,9	18,9	22,0	11,2	7,7	7,9	3,4	25,5	41,3
555	70,4	64,5	18,1	9,5	7,9	13,1	13,9	26,8	10,4	7,2	11,8	12,8	23,6	24,2	13,4	10,2	9,1	4,4	32,0	48,2
644	70,4	66,0	16,9	9,6	7,4	12,7	13,9	28,2	11,0	7,4	10,2	13,1	21,7	25,9	13,3	8,4	9,6	3,7	30,8	48

All % are given as a % of entering wheat

Practical example 1
5 Samples with same Extraction rate and different MPi



Looking at	Average	Range	Variation
Feeding 2nd Break	6 t/h	1t/h	+/- 17 %
Feeding Sizing	2,5t/h	1t/h	+/- 40 %
Feeding Reduction	4,2 t/h	1,3 t/h	+/- 31 %

- Same flour extraction can ne obtained with samples responding very differently to the milling process.
- In the industry this can generate difficulties at different stages (grinding, sifting…)

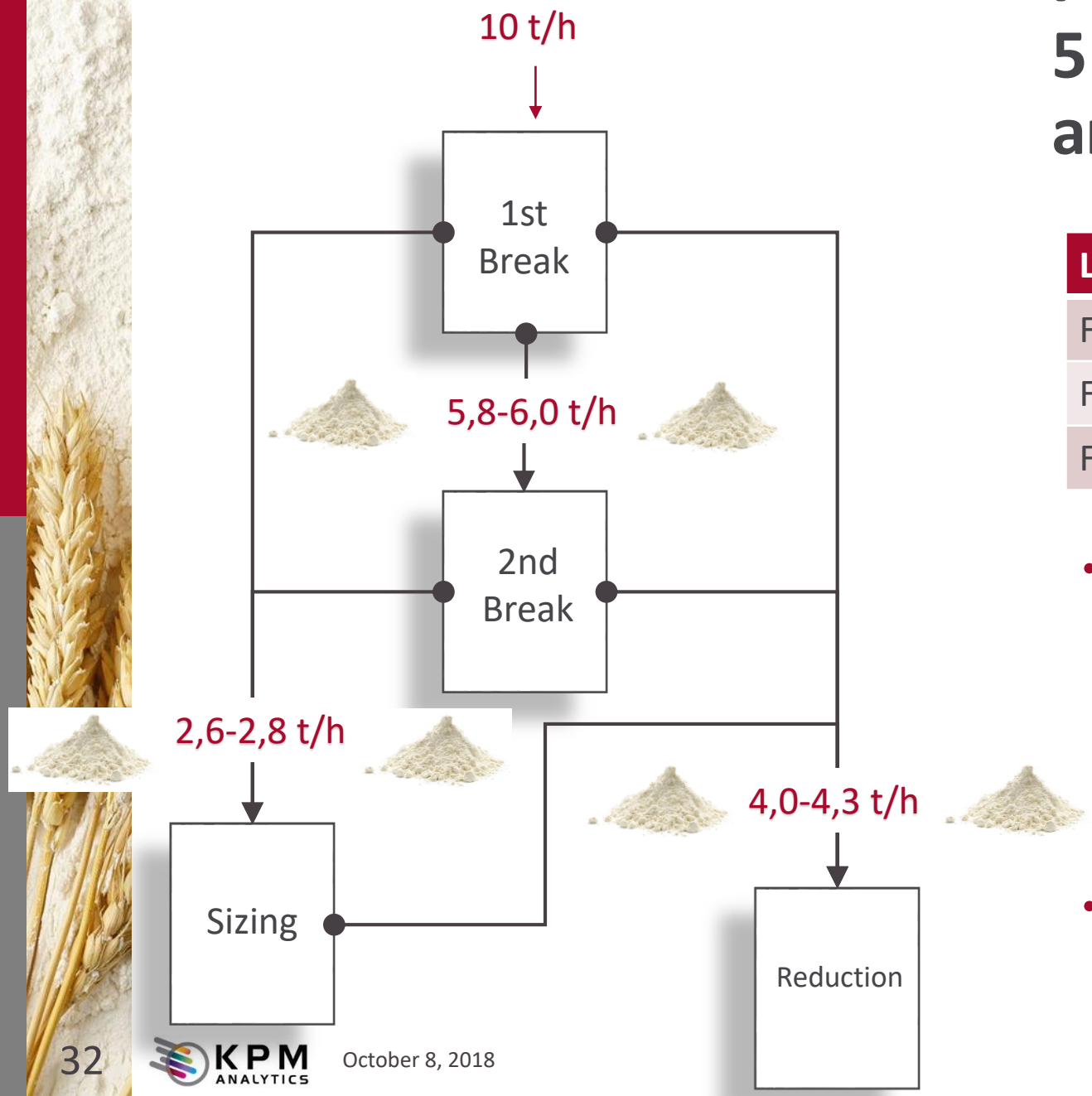
Feed numbers in t/h are hypothetical, helping comparison –not example of existing situation-

Practical example 2
5 samples with same MPi and different Extraction rate

MPi	Extraction rate (%)	Meal/B1 (%)	Large Middlings B1 (%)	Fine Middlings B1 (%)	Flour B1 (%)	Coarse Bran (%)	Large Middlings/B2 (%)	Fine Middlings/B2 (%)	Flour B2 (%)	Fine Bran (%)	Fine Middlings/Sizing (%)	Flour Sizing (%)	Fine Middlings/Red1 (%)	Flour/Red1 (%)	Fine Middlings/Red2 (%)	Flour/Red2 (%)	Fine Middlings/Red3 (%)	Flour/Red3 (%)	Feed material → Sizing (%)	Feed Material → Reduction (%)
344	70,4	59,9	16,1	11,4	12,4	15,7	9,8	22,2	11,9	5,8	7,7	12,3	19,5	21,3	11,5	8,0	8,2	3,4	25,9	41,3
344	71,7	58,4	16,4	11,8	13,4	14,5	9,4	21,8	12,3	5,9	6,9	12,9	18,5	21,6	10,7	7,8	7,7	3,0	25,8	40,5
344	72,9	59,6	16,2	11,0	12,8	15,4	9,9	21,8	12,2	5,1	7,2	13,5	16,0	23,8	9,0	7,0	6,3	2,7	26,0	40,1
344	73,8	57,3	17,4	12,0	13,2	14,2	8,9	21,5	12,5	5,8	6,8	13,6	15,7	24,2	8,5	7,2	5,9	2,6	26,3	40,2
344	74,8	58,8	17,4	11,3	12,4	13,0	10,2	23,6	11,8	5,6	8,4	13,3	16,3	26,5	8,9	7,4	6,3	2,6	27,5	43,3

All % are given as a % of entering wheat

Practical example 2
5 Samples with same MPi and different Extraction rate



Looking at	Average	Range	Variation
Feeding 2nd Break	5,9 t/h	0,2 t/h	+/- 3 %
Feeding Sizing	2,7 t/h	0,2 t/h	+/- 7 %
Feeding Reduction	4,15 t/h	0,3 t/h	+/- 7 %

- Because it is based on the observation of wheat behavior during crushing MPi classifies wheat according to their response to milling stress.
- This allows a new and useful way to look at Laboratory milling results.

Feed numbers in t/h are hypothetical, helping comparison –not example of existing situation-

Wheat milling behavior at a glance :

a comprehensive summarizing spreadsheet

1/ Indicate the test conditions

2/Enter the weight of the different fractions

3/you can add flour ash content

/03/2018				Operator	A. Dubat		
Sample identification		58-ARG-BL-INT					
Wheat input (g)		1700		Comments			
Wheat initial moisture (%)							
Wheat moisture for milling (%)		15,9					
Tempering time (h)		24					
		Weight (g)	%/Wheat	%Stream Feed	Resistance index	Dissociation index	Conversion index
1st Break	Meal/B1	1040,4	61,2%	6[illegible]%	0,26	1,26	0,85
	Large Middlings	301,9	17,8%	17,8%			
	Fine Middlings	186,4	11,0%	11,0%			
	Flour	168,4	9,9%	9,9%			
2nd Break feed material		1040,4	61,2%	100,0%			
2nd Break	Coarse Bran	272,9	16,1%	26,2%			
	Large Middlings	165,0	9,7%	15,9%			
	Fine Middlings	402,3	23,7%	38,7%			
	Flour	196,3	11,5%	18,9%			
Sizing feed material		466,9	27,5%	100,0%			
Sizing	Fine Bran	89,0	5,2%	19,1%			
	Fine Middlings	131,4	7,7%	28,1%			
	Flour	243,9	14,3%	52,2%			
1st reduction feed material		720,1	42,4%	100,0%			
1st reduction	Fine Middlings	269,9	15,9%	37,5%			
	Flour	443,4	26,1%	61,6%			
2nd Reduction	Fine Middlings	146,9	8,6%	54,4%			
	Flour	124,3	7,3%	46,1%			
3rd Reduction	Shorts	101,3	6,0%	69,0%			
	Flour	44,9	2,6%	30,6%			
Total product recovered		1684,4	99,1%				
Total Flour		1221,2					
Extraction rate		**72,5%**					
Flour Ash Content							

Milling Performance Index (MPi)

4	**4**	**4**
Higher index (7) indicates more resistance to crushing	Higher index (7) indicates more resistance to create fine particles	Higher index (7) indicates more resistance to flour production from fine middlings

Apparent Hardness Index

57

Scale ranges from 0 (soft) to 100 (Hard)

Actual sample | Graphical analysis | Tables for comparison

All fractions are automatically calculated, based on wheat weight and on the fraction of product entering the stream

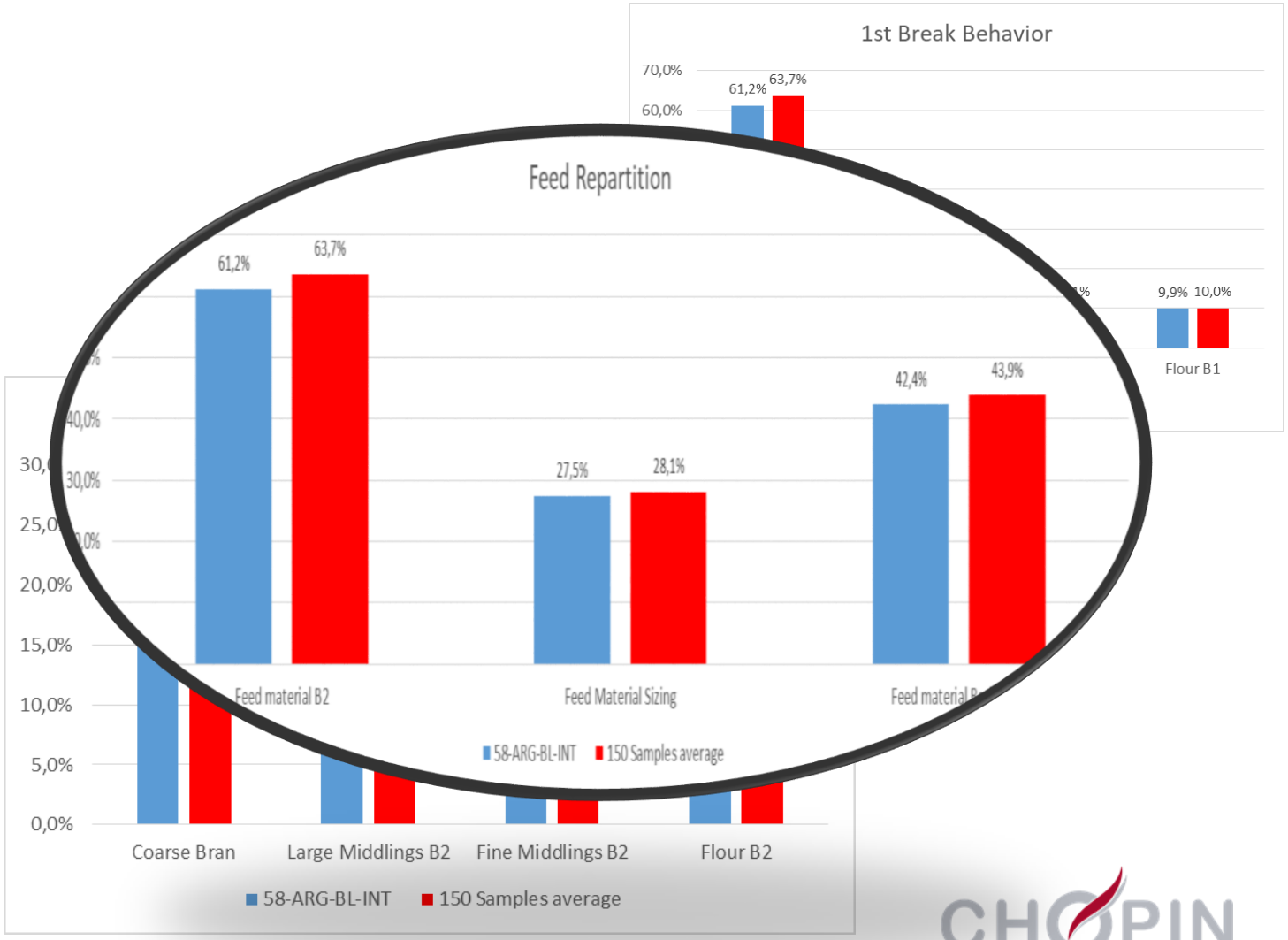
Milling Performance Index
automatically calculated

Apparent Hardness
automatically calculated

Extraction Rate
automatically calculated

Wheat milling behavior at a glance :

and a graphical visualization of the results



CHOPIN TECHNOLOGIES

Let’s start REALLY analyzing wheat milling

- The Milling Value index is a new parameter that helps understanding wheat behavior during milling.
- Certain wheat can have high extraction potential but grinding characteristics not suitable for certain mil diagrams.
- Selecting wheat according to their potential extraction AND behavior during milling makes sense to ensure that incoming wheat is adapted to millers needs.

Presentation Map

LabMill Presentation

Precision of the LabMill

Simplifying the data reading

Comparison with industrial mill

Blending wheat with the LabMill

LABMILL

Comparison with the French reference Pilot mill (ENILIA-ENSMIC, Surgères)

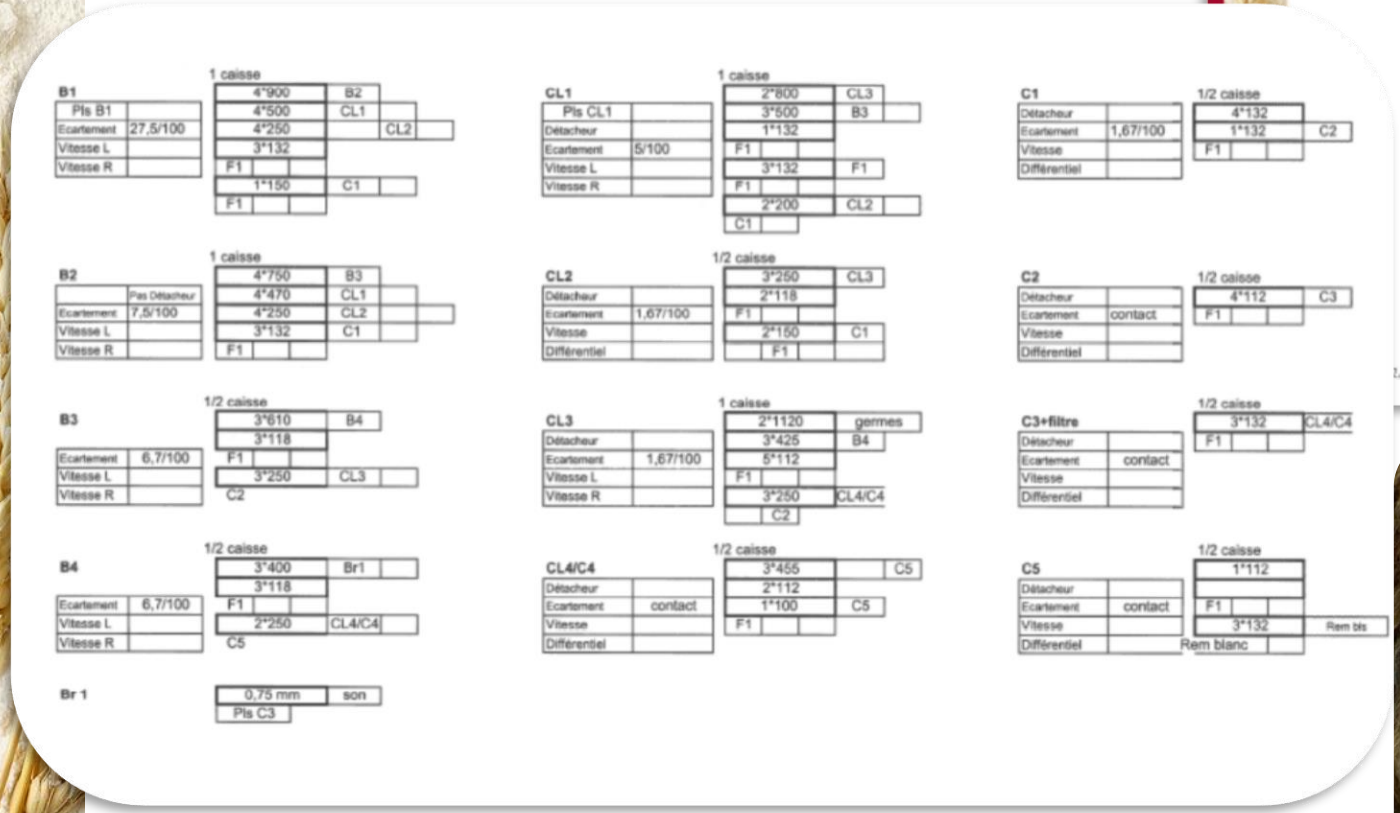
introduction

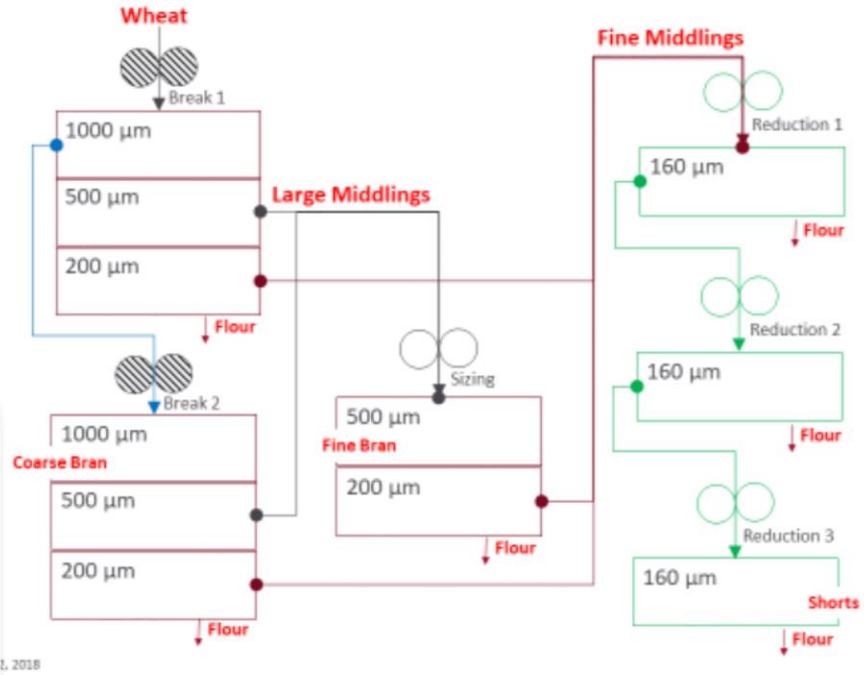
- The objective is to compare milling behavior of the CHOPIN LabMill with the French reference Pilot mill on 22 wheat samples.

- The LabMill was used according to the classical tempering protocol (ISO 27971) 16% moisture, 24H resting time. Only 2 reductions were used instead of 3. (Tess done by Arvalis-institut du végétal)

- At the Pilot mill level, all tempering were conducted at 16% moisture (except for 4 wheat tempered at 16,5%). Resting time was 48 hours. Tests done by Enilia-Ensmic.

What are we comparing??

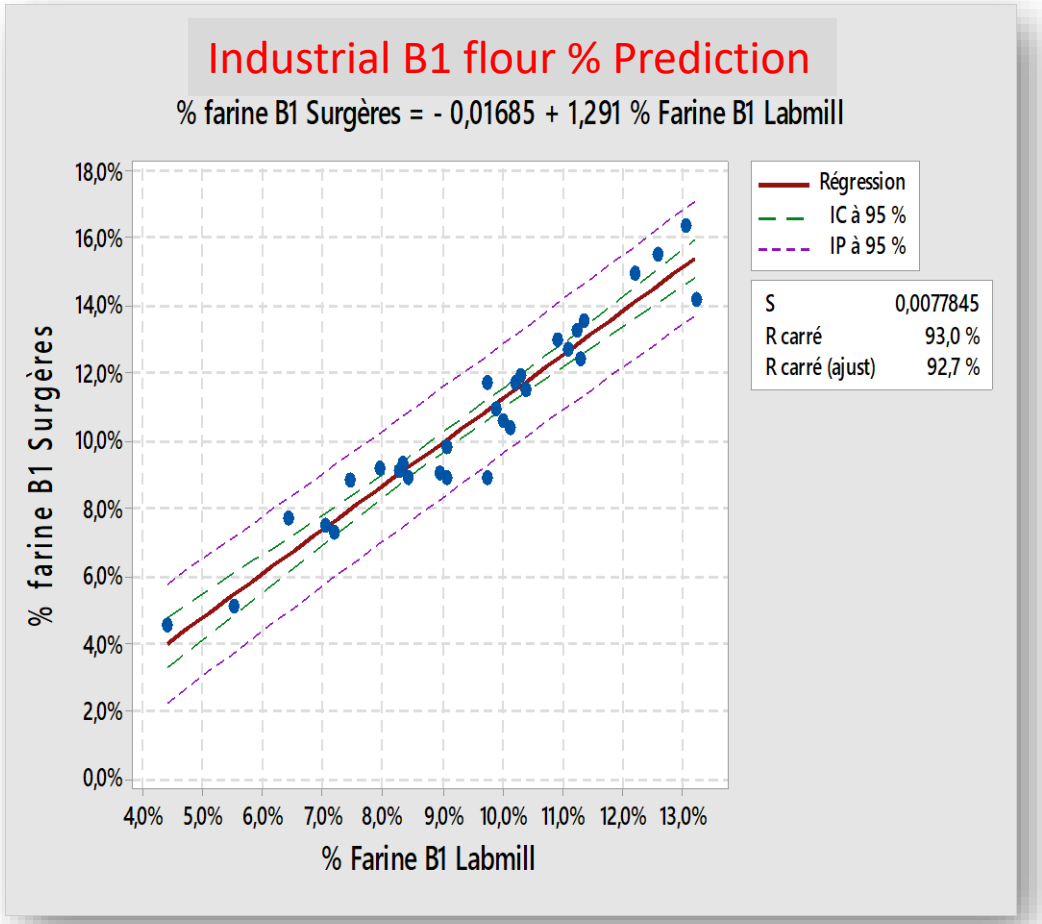




LabMill Diagram and products

A direct prediction of B1 flour !

Labmill Predictor For industrial B1 flour	Coef Correlation (r)
% Farine B1	**0,964**
% Total middlings	-0,910
% Fine middlings B1	0,891
% Fine middling total	-0,889
% Fine middling B2	-0,878
% Flour C2	-0,861
% Fine middling Sizing	-0,854

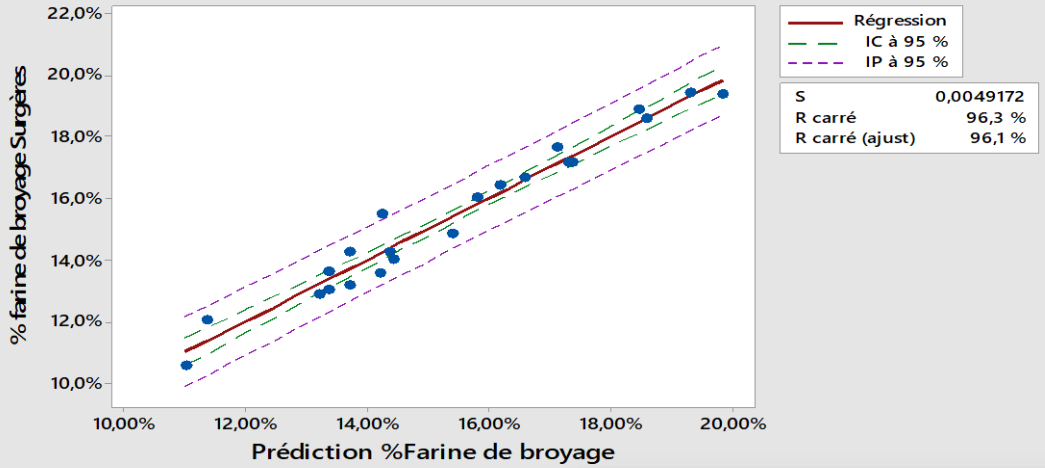


Wheat behavior at B1, directly related to their resistance to crushing, confirms the strong prediction potential of the LabMill. This results is important as it shows the achievable analogy between Laboratory and industrial milling.

Prediction of main flour production zone

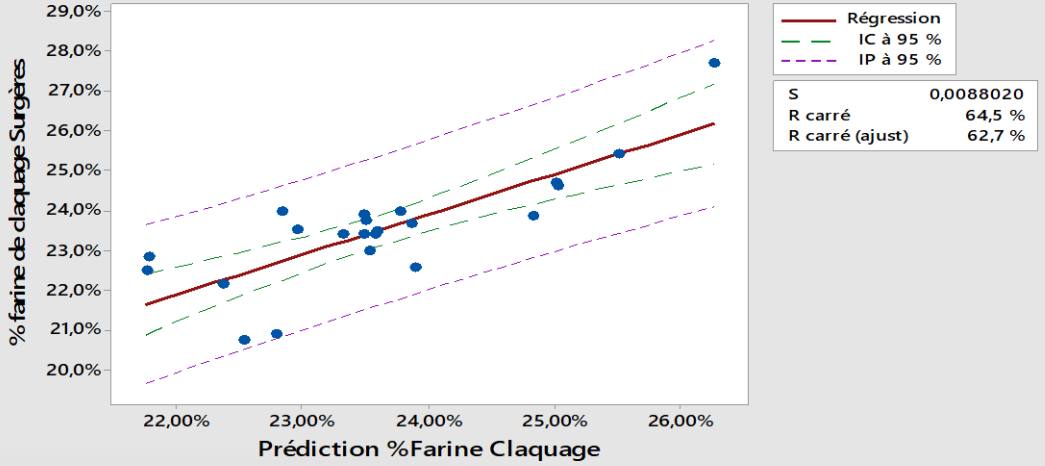
Break flour % Prediction

% farine de broyage Surgères = 0,000187 + 0,9994 Prédiction %Farine de broyage



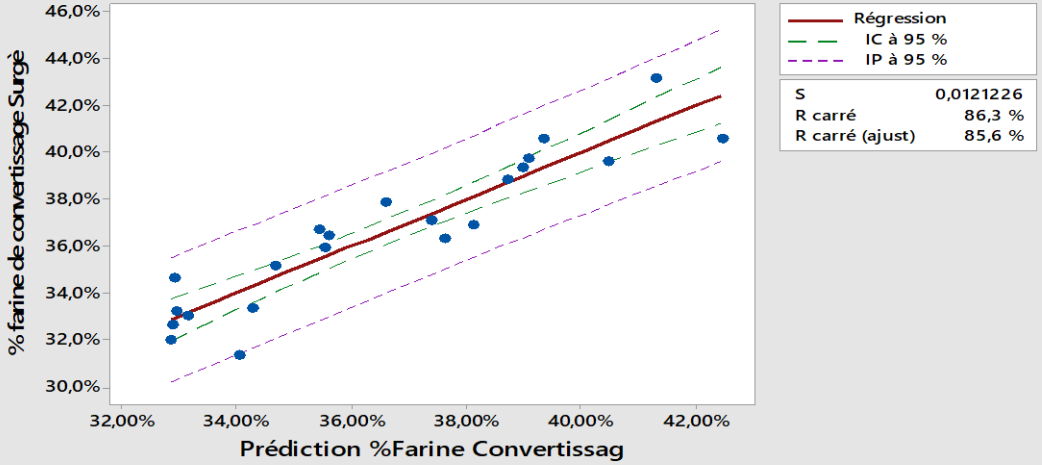
Sizing flour % Prediction

% farine de claquage Surgères = - 0,00217 + 1,005 Prédiction %Farine Claquage

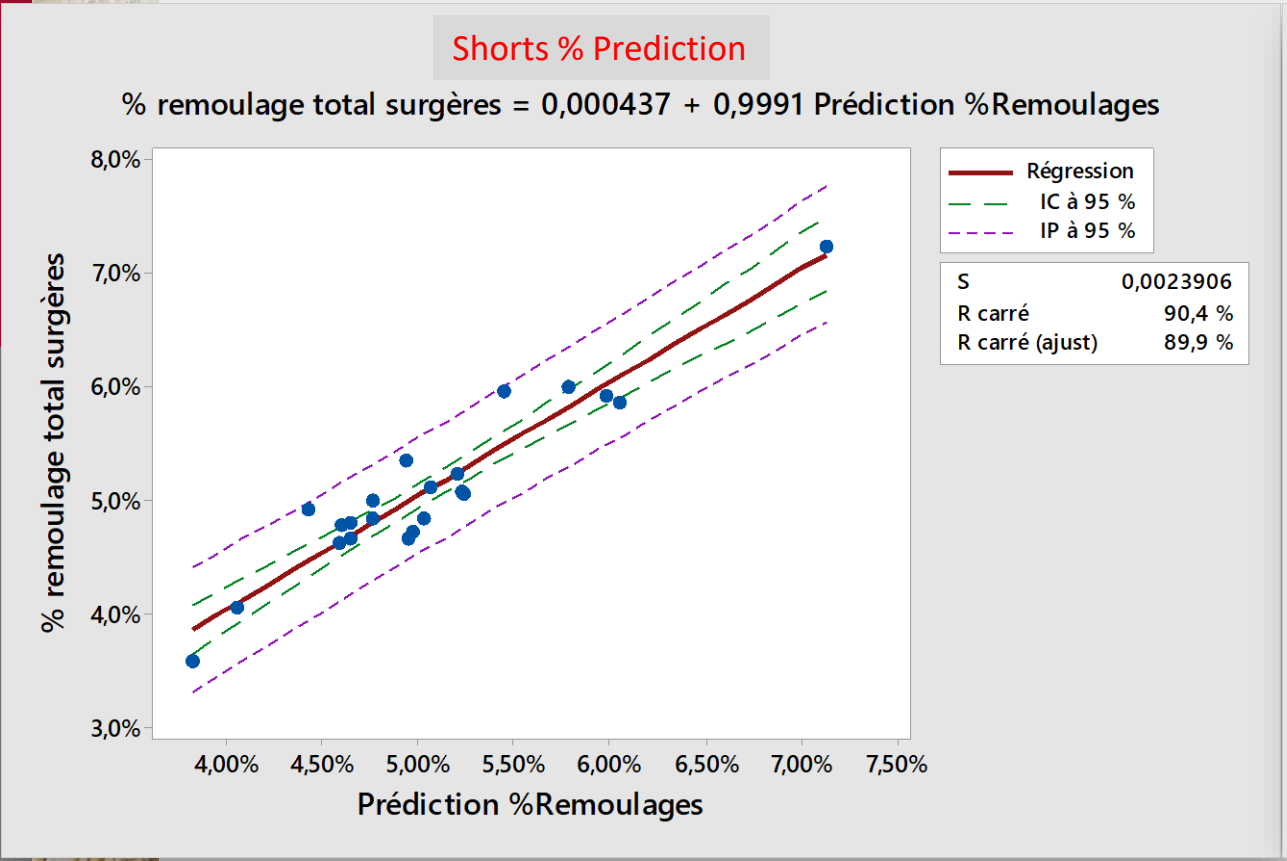


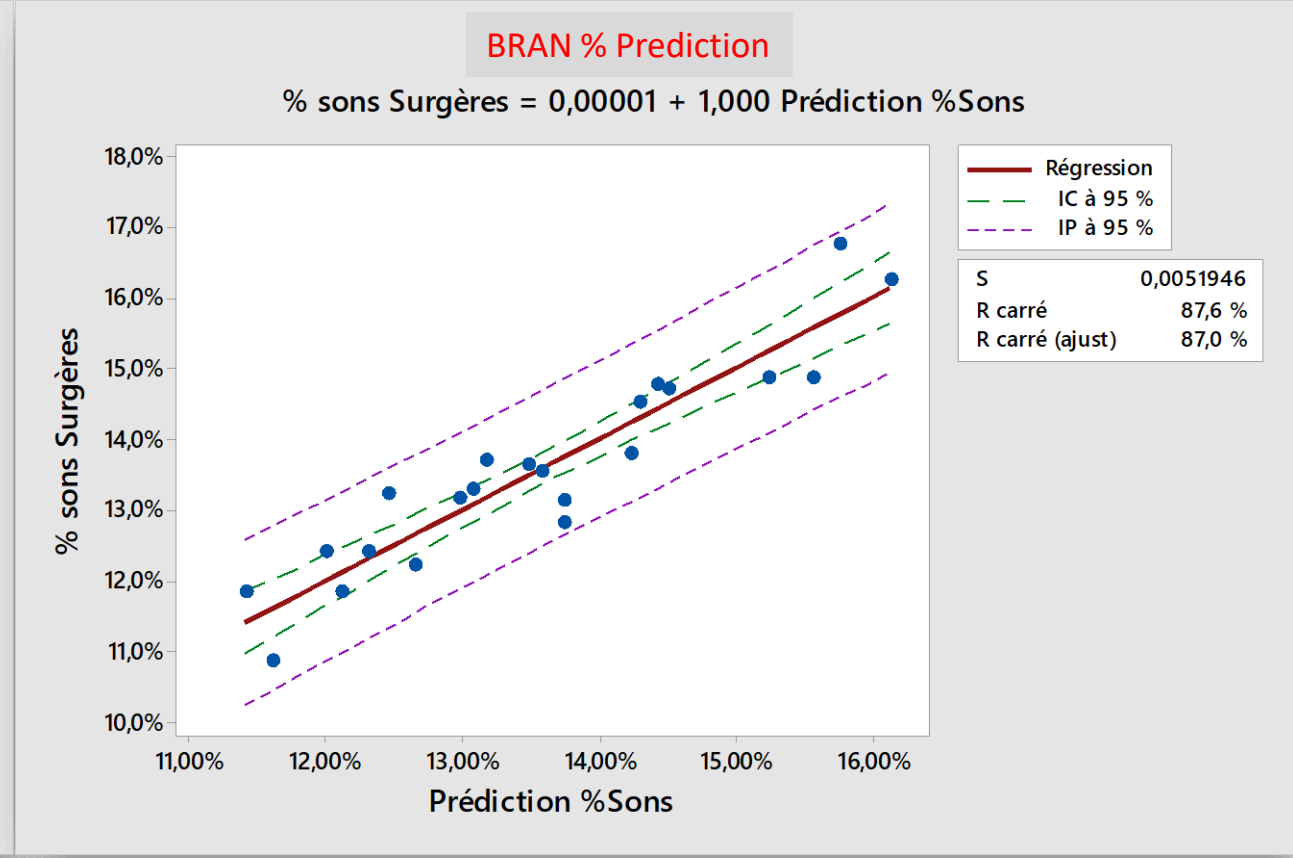
Reduction flour % Prediction

% farine de convertissage Surgè = 0,00117 + 0,9966 Prédiction %Farine Convertissag

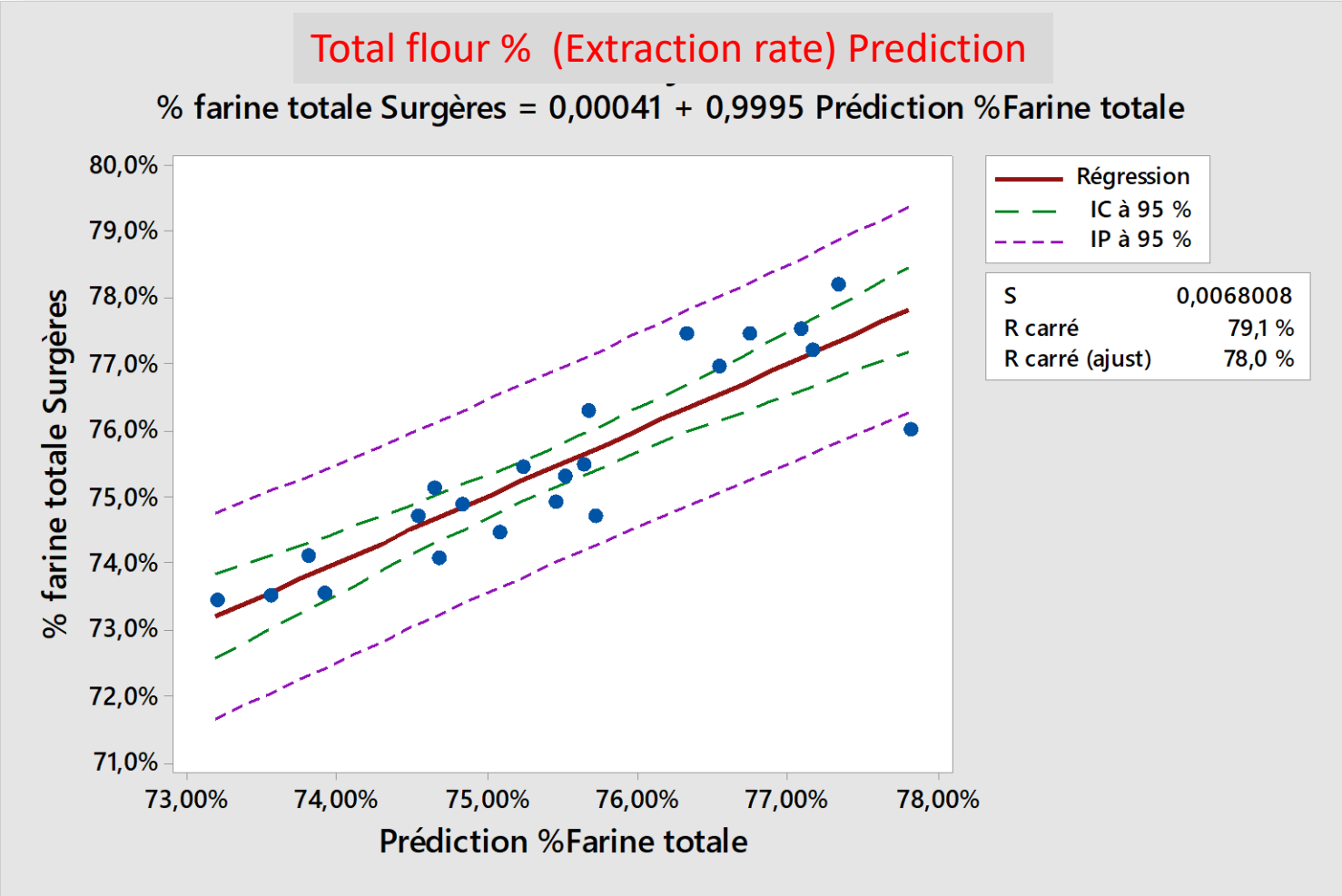


Bran & shorts prediction





Extraction rate prediction



Conclusion

- Results analysis shows a great potential of the LabMill to predict Surgères Pilot mills results.

- At this stage, and taking into consideration that 1/Laboratory and industrial diagram are strongly different and 2/normal measurement uncertainty at lab and on line, these results are very encouraging and show a great potential to create the missing link between the Laboratory and the production plant.

Presentation Map

LabMill Presentation

Precision of the LabMill

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Blending wheat with the LabMill

LABMILL

How to measure blending law?

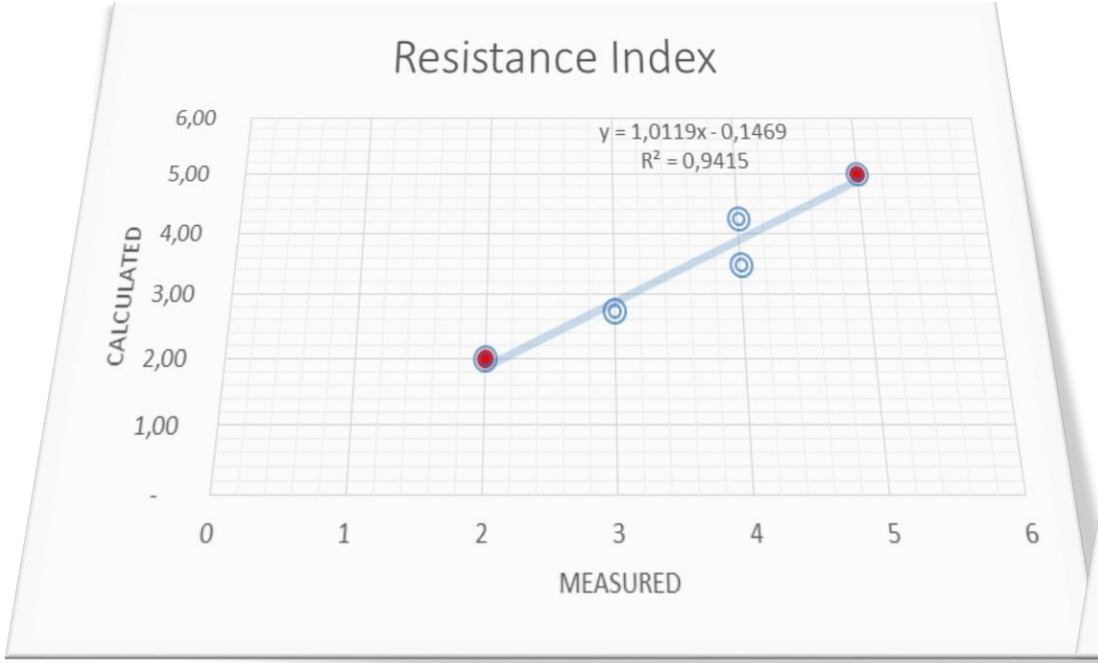
Analytics

- 2 wheats : Hard and Soft
- Blending :
  - 100% Hard
  - 75% Hard + 25% Soft
  - 50% Hard + 50% Soft
  - 25% Hard +75% Soft
  - 100% Soft
- Tempering 24h, 16% H2O
- LabMill (standard settings)
- Analytical
  - Alveograph HC
  - Spectralab (Moisture, protein, ash)
  - SDmatic (Starch Damage)
  - CHOPIN-SRC

Data study

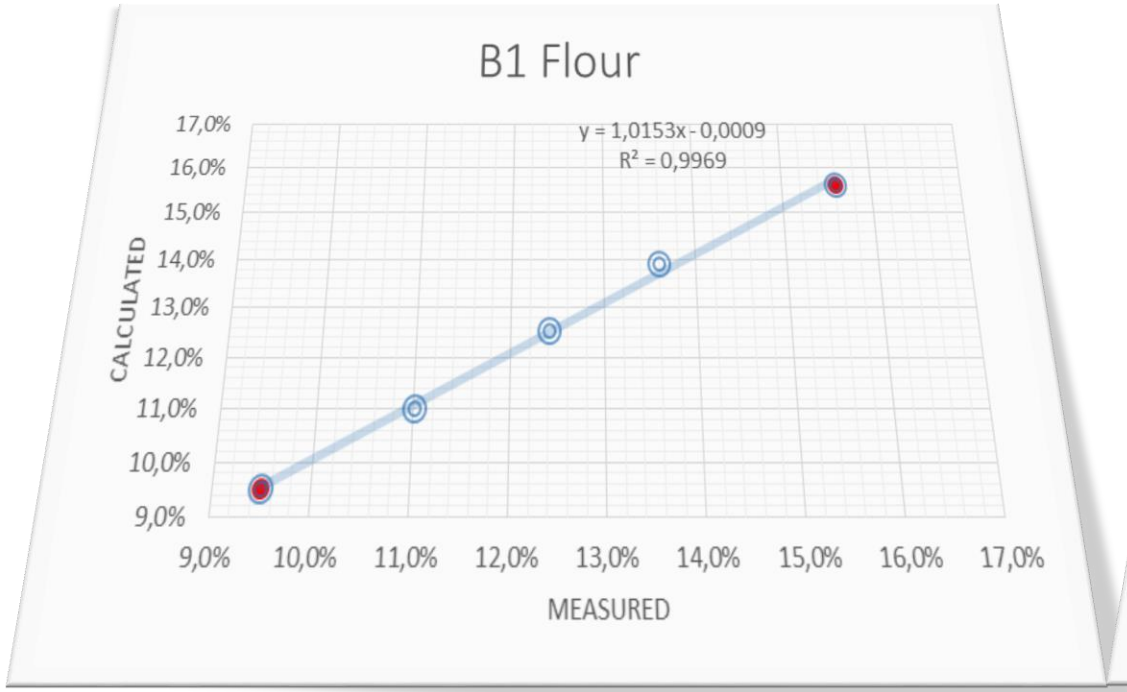
- Calculate blending values according to the wheat blending (calculated values)
  - Example 50/50
    - Calculated value = 50% real Hard wheat value + 50% real Soft wheat value
- Compare calculated value vs real value
- Assess coefficient correlation (r^2)

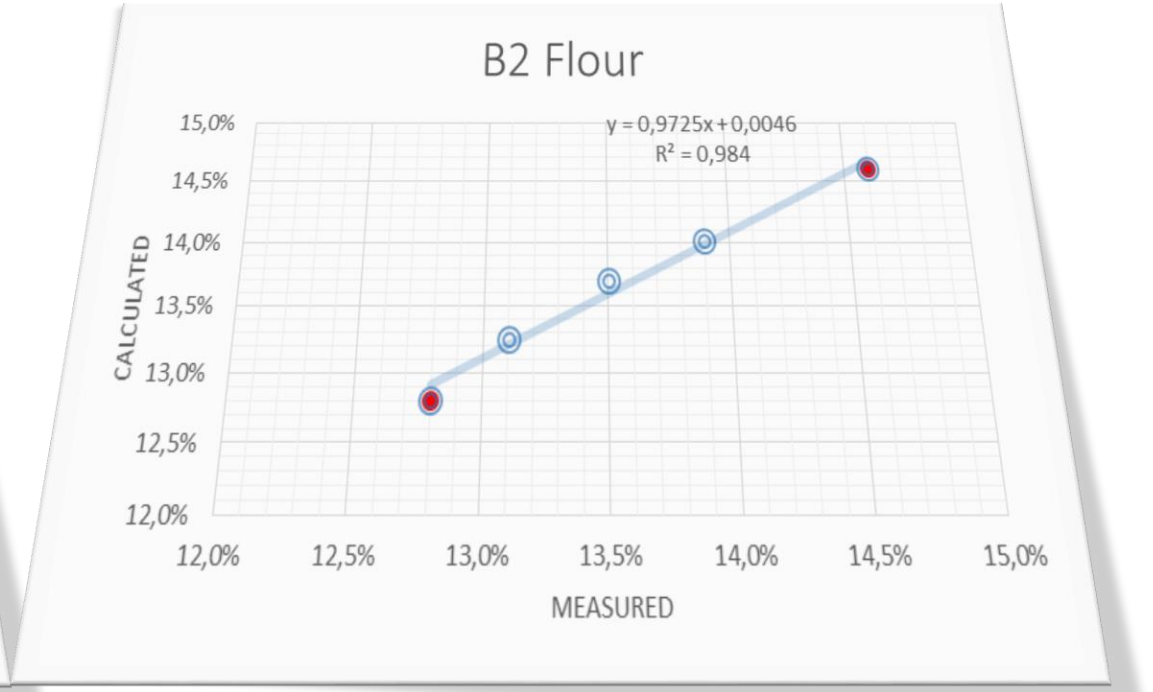
MPI based indexes



- It is possible to base wheat blending on
  - Resistance Index (the most important of the 3 indexes) (r^2=0,94)
  - Apparent Hardness index (r^2=0,99)

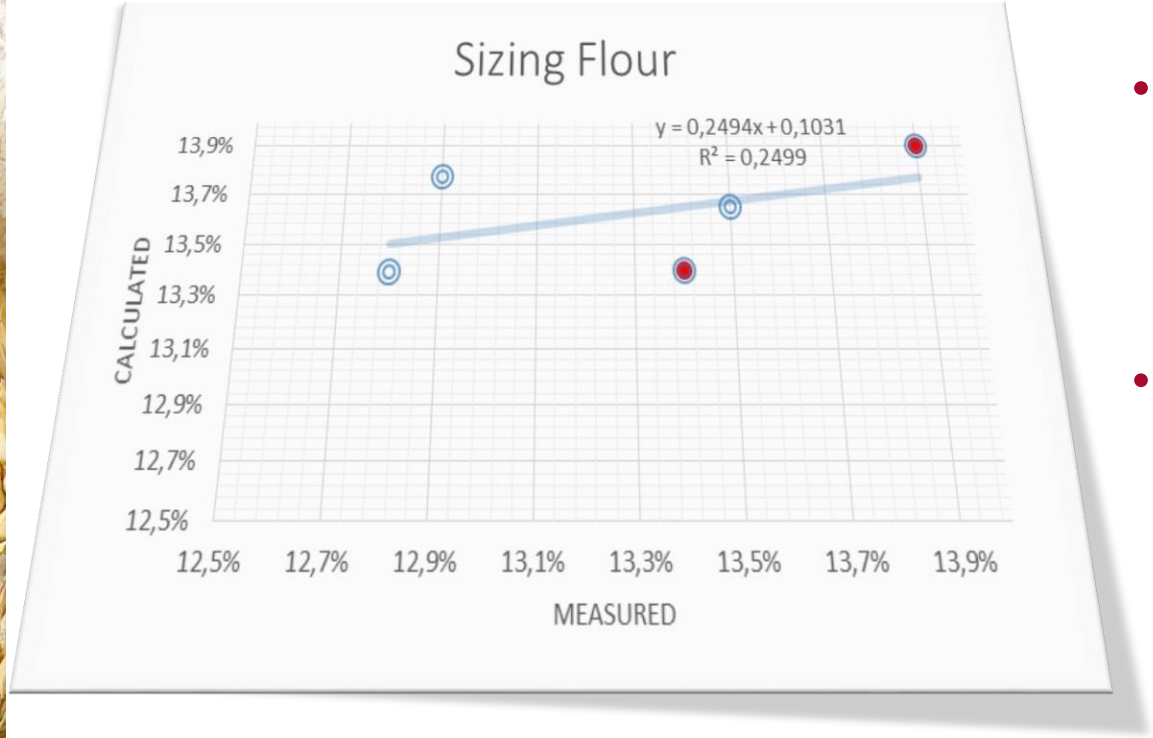
Break Flour





- 1st and 2nd Break flour perfectly respond to blending law (r^2=0,99 and 0,84 respectively)

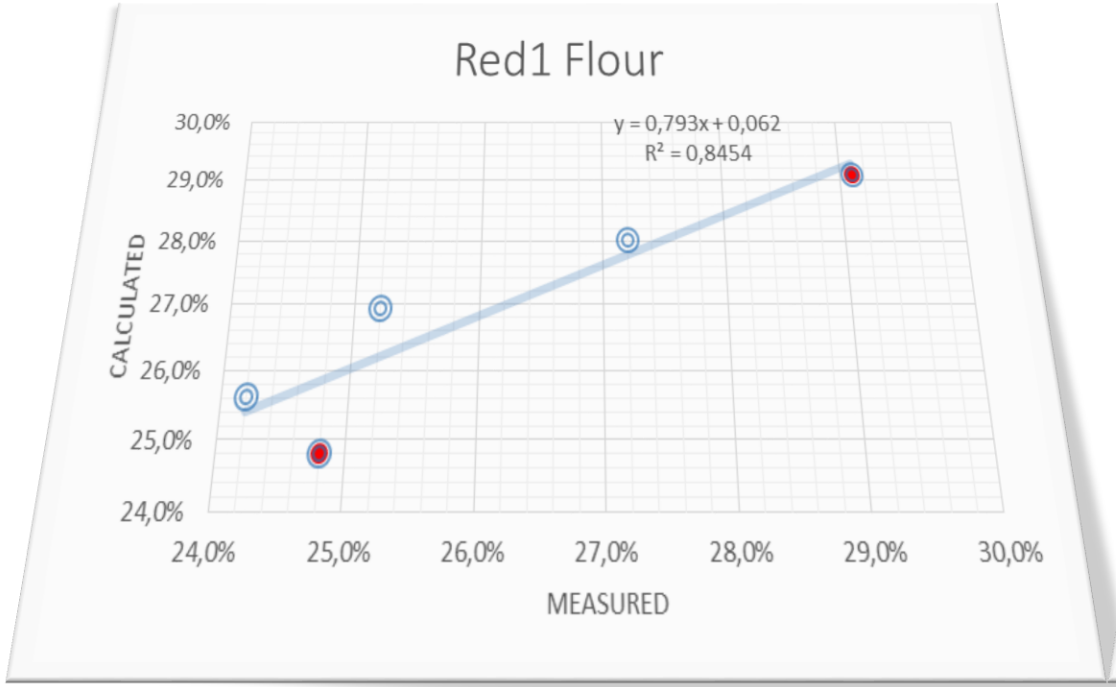
Sizing flour

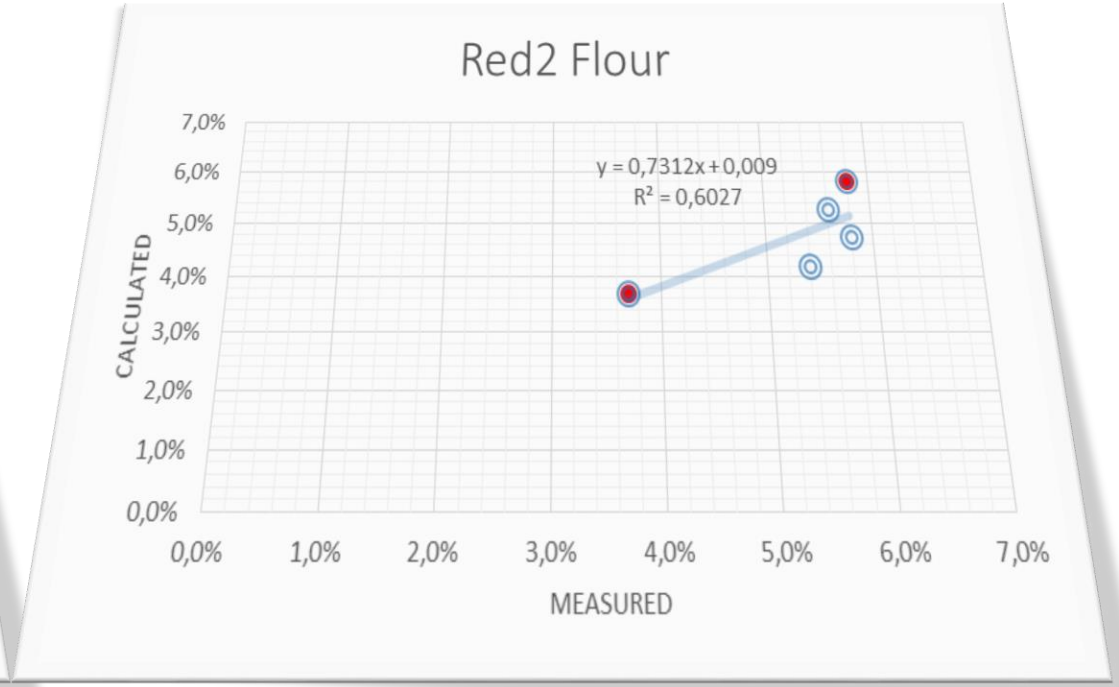


- Sizing flour does not look to respond blending law.
- This is directly related to very little variation in flour production at this stage between soft and hard wheat (0,5%)
- In this study, this value is a constant.

	Measured	Calculated
Average	13,3%	13,6%
Mini	12,8%	13,4%
Maxi	13,9%	13,9%

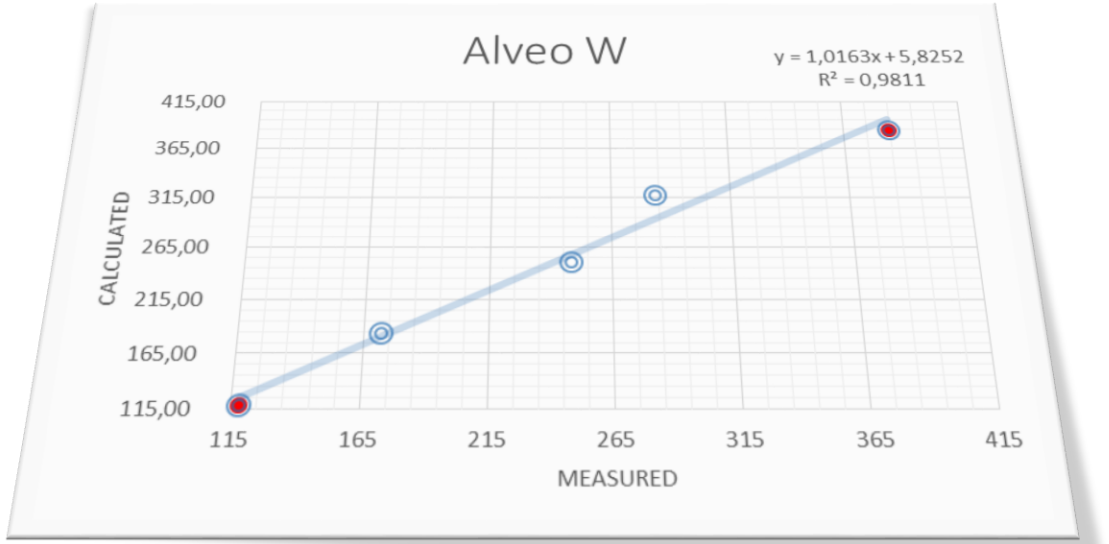
Conversion flour

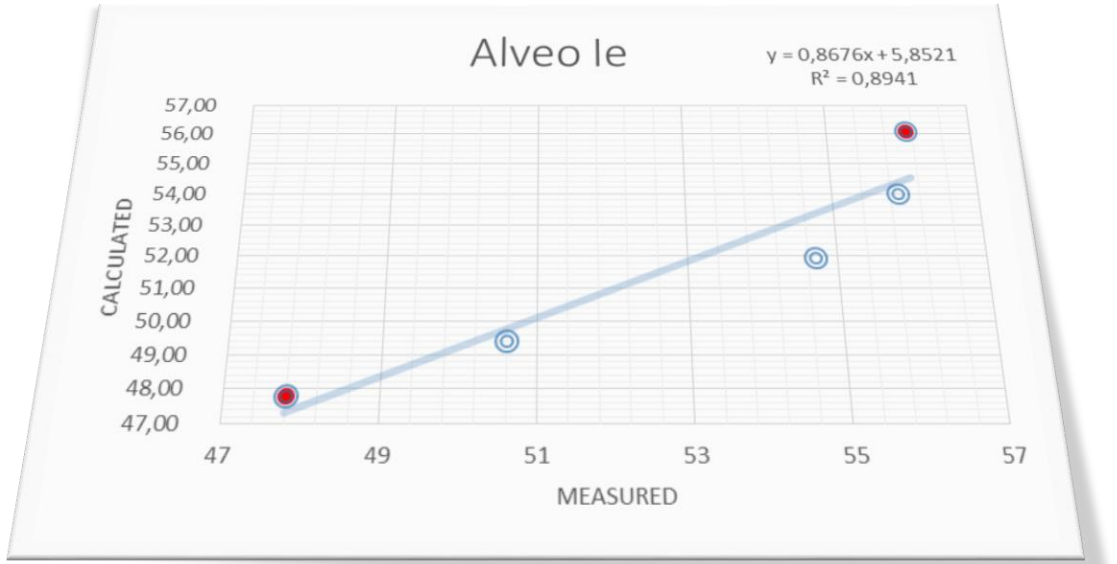


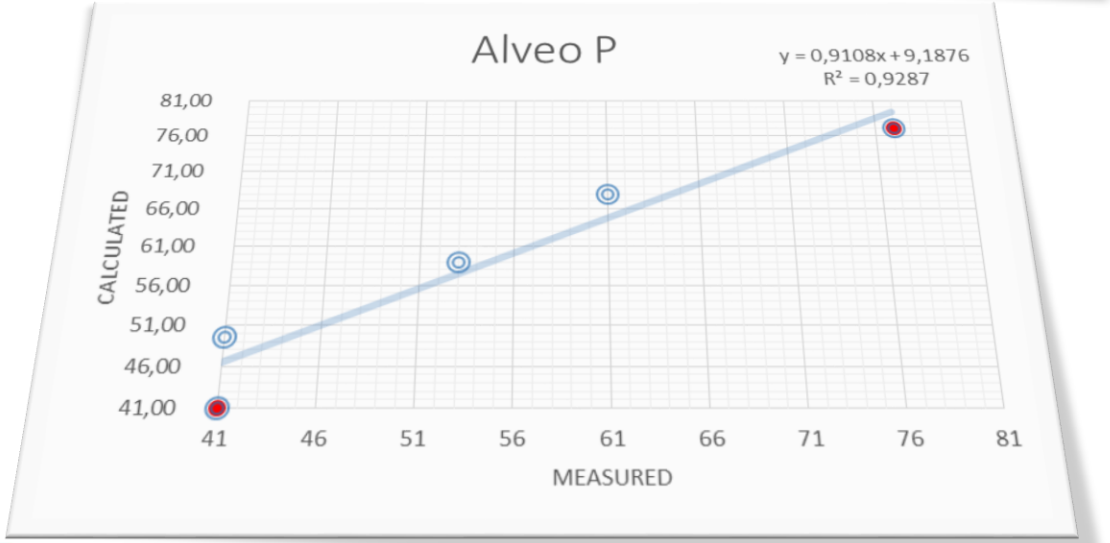


- Red 1 responds well to blending law (r^2=0,84)
- Red2 responds less (r^2=0,60) but, here again, variation between hard and soft is very limited (2%) (same for Red3 –not shown here)

Alveograph







- Alveograph data respond very well to blending law. (R^2= 0,98 for W and P, 0,89 for Ie)
- This was already known blending flour, it is confirmed blending wheat on the LabMill

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Conclusions

- Using the blending law with the LabMill works* for predicting:
  - MPI and apparent hardness values
  - Different streams products
  - Flours quality

- This means that the LabMill is a suitable tool to:
  - Predict the final result and optimize the blending of 2 wheats
  - Calculate the « ideal » wheat to correct a deficient one.
    - Example : you have a wheat with apparent hardness 80, you want to blend it 50/50 with another one and have final apparent hardness 85
    - 85 = 0,5*80 + 0,5*? → ? = (85-(0,5*80))/0,5 = 90

* When 100% values of both wheat are sufficiently different and not within the method uncertainty

Conclusions

- Laboratory milling is more than just grinding wheat to obtain flour.
- By analyzing how the wheat performs in the experimental mills, this gives a good image of how it will perform in the industry.
- Based on this, it allows select wheats or blend them not only looking at extraction rate but considering the complete behavior during milling.

- A complete information

Extraction + Milling behavior

Repeatability
Reproducibility

- A precise tool

- A simple experience for users

Comprehensive MPI indexes

Blending law

- That allows to select/blend wheats

- Data comparable to industrial mills

Pilot mill study

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