Flour Milling Applications of the Alveograph

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What is the objective of Alveograph?

➢ The alveograph measures resistance of dough to extension and extent to which it can be stretched under the conditions of the method.

• In this method (AACC Method 54-30.02; Alveograph Method for Soft and Hard Wheat Flour) a sheet of dough of definite thickness prepared under specified conditions is expanded by air pressure into a bubble until it is ruptured. The internal pressure in bubble is graphically recorded on moving paper or automated integrator.

CEREALS & GRAINS ASSOCIATION

AACC Approved Methods of Analysis • 11th Edition

Alveograph Video!

The Alveograph was invented 100 years ago!

In the 1920's, Marcel Chopin became interested in the possibility of using dough-testing instruments in place of baking tests to assess the baking quality of French wheats. He attempted to develop a test would simulate, as closely as possible, the process that dough undergoes in bread baking.
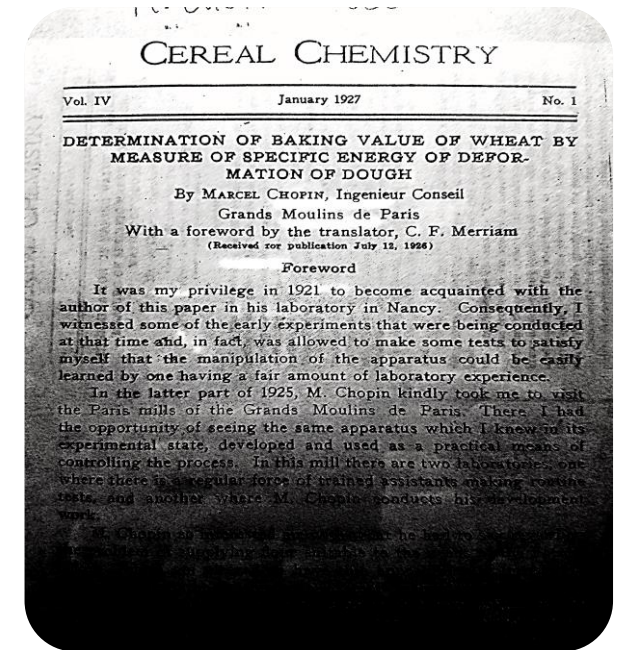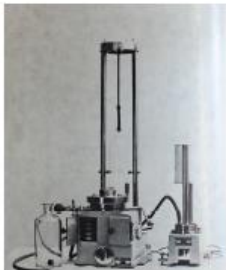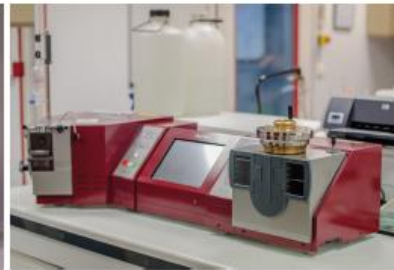
A constant evolution…
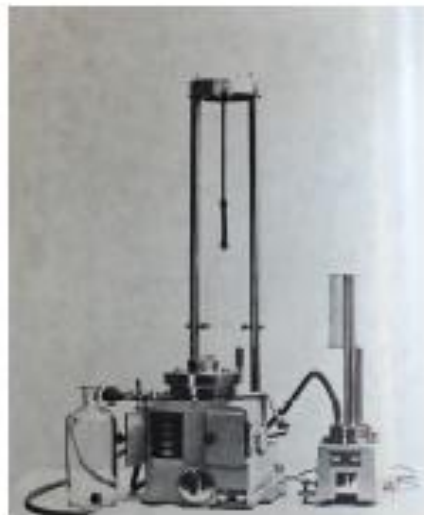
1920s

2014

1926
1er
Alvéographe

1982
Alvéographe
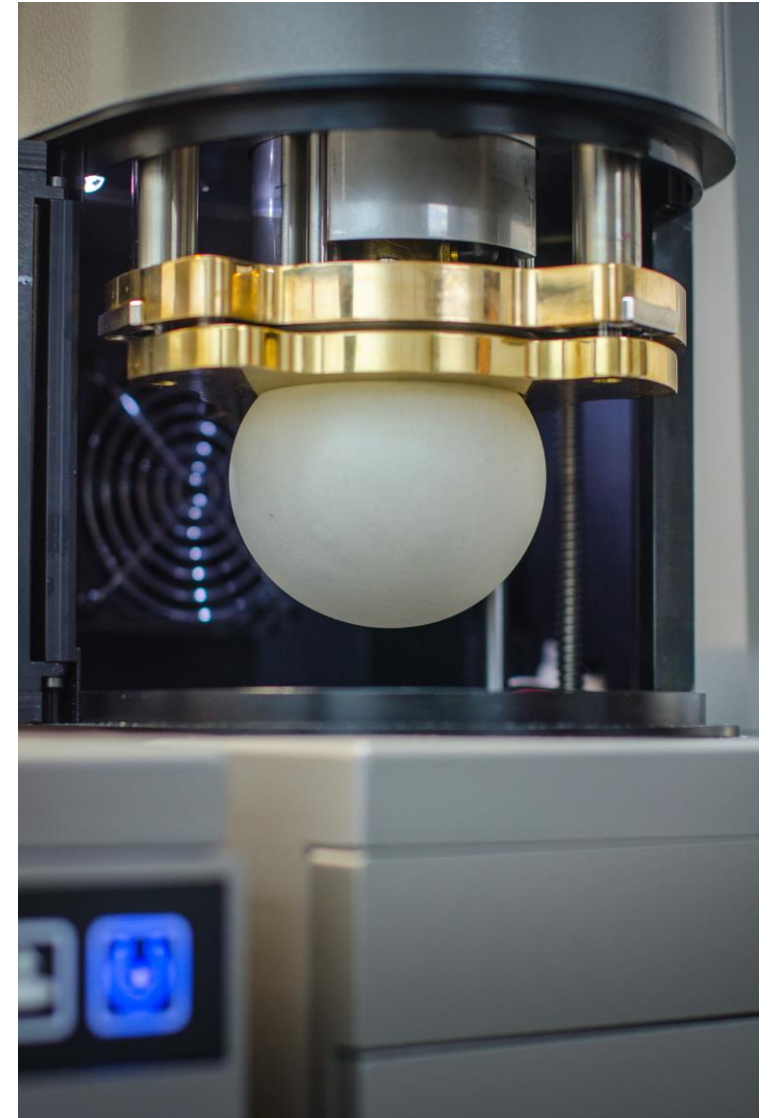MA 82

1987
Alvéographe
MA 87

1998
Alvéographe
NG

2014
AlveoLab
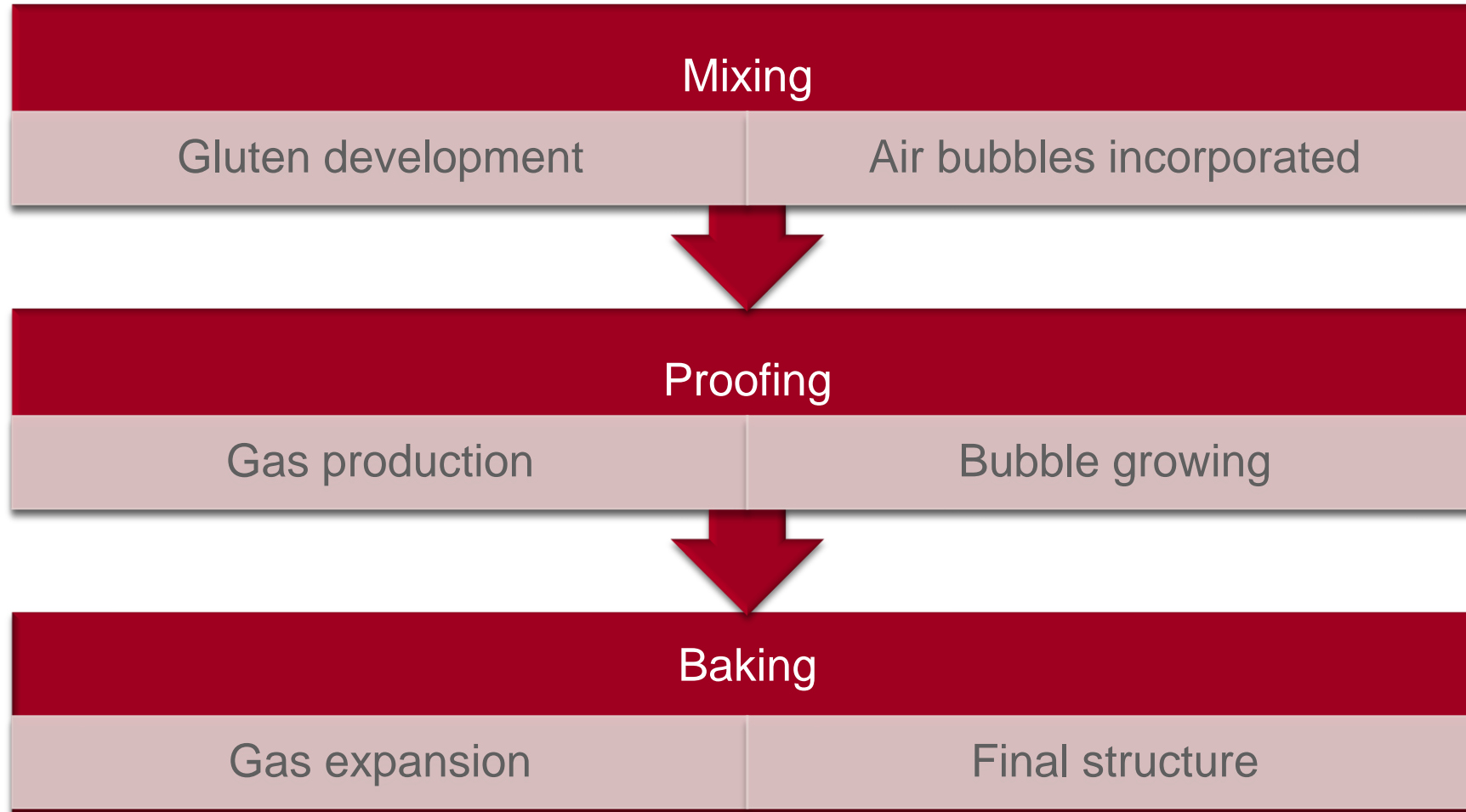
… but the same principle

One instrument to measure the viscoelastic properties of a bubble of dough as it is inflated

Baking, a matter of bubbles!

Baking, a matter of bubbles!

Mixing	
Gluten development	Air bubbles incorporated

Proofing	
Gas production	Bubble growing

Baking	
Gas expansion	Final structure

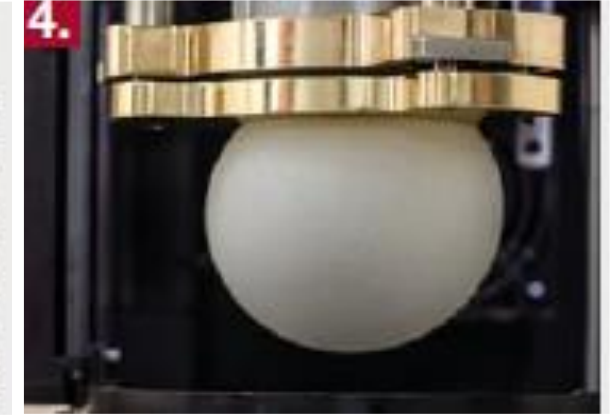# The Alveograph standard test (Hyd 50%, base 15)

Mixing
8min
24°C

Extrusion
+
shaping

Resting
20min
25°C

Blowing
20°C
65% RH

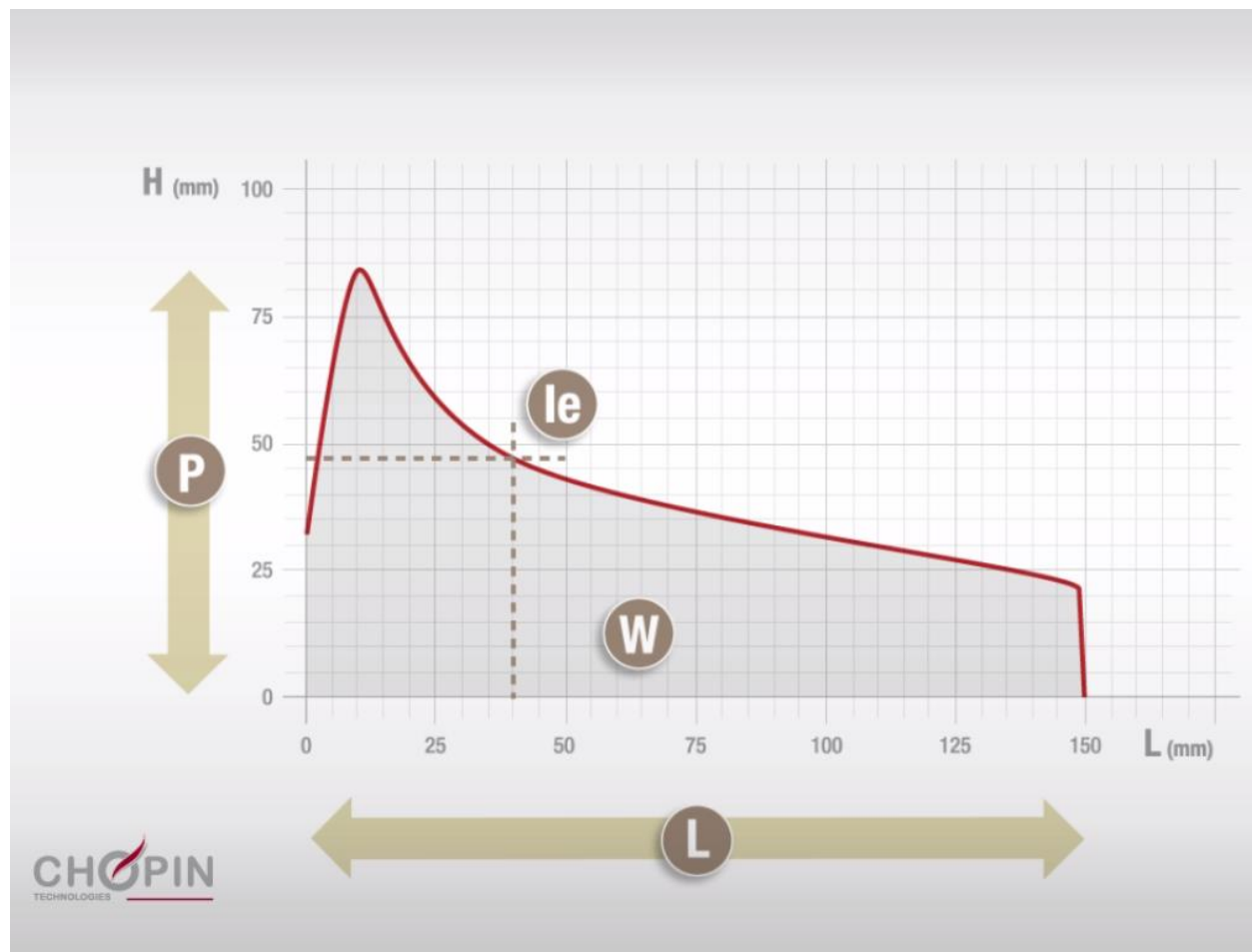# The test results!

How to read an Alveographic curve?

What do we measure?

➢ The Alveograph is an instrument for measuring the properties of a bubble of dough as it is inflated.

• → *tenacity, extensibility, elasticity and baking strength*

➢ An Alveograph is always composed of two inseparable parts: the kneader and the Alveograph itself.

Characteristic curve

Specifying flour based on Alveograph measurements :

- **P: Tenacity** of the dough
(capacity to resist deformation)

- **L: Extensibility** of the dough
(maximum volume of air the bubble can contain)

- **P/L:** Curve configuration ratio

- **Ie: Elasticity index**, Ie = P200/P
(P200: pressure at 4 cm from the beginning of the curve)

- **W: Dough baking strength**
(area under the curve) or Energy value

Baking strength, W

➤ The parameter **W** is called the deformation energy, as it represents the energy required to inflate the dough bubble until rupture.

➤ It is sometimes referred to as flour strength, dough strength, baking strength or flour protein/gluten strength.

➤ W can be used to divide different cultivars into groups with different strength. In flour specifications for different types of bakery products, W can be applied (possibly together with P/L), as e.g., bread flours are characterized by larger W values compared to biscuit flours.

➤ Positive, significant correlations ($p < 0.05$) have previously been found between W and bread volume!
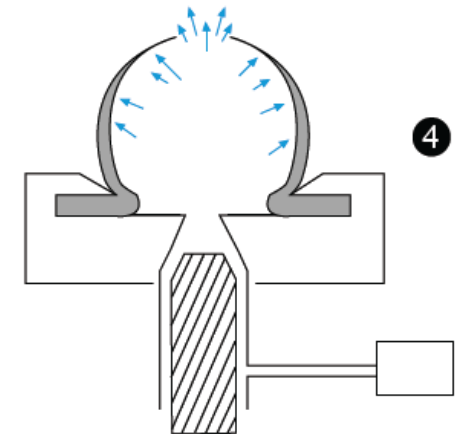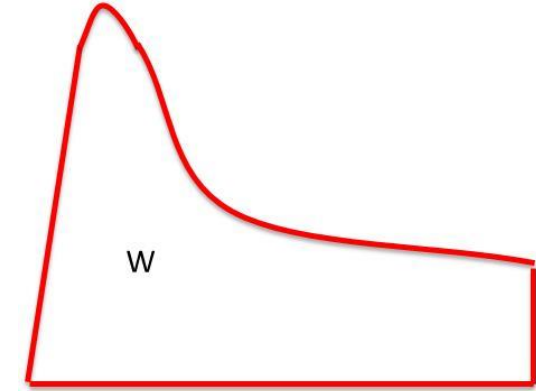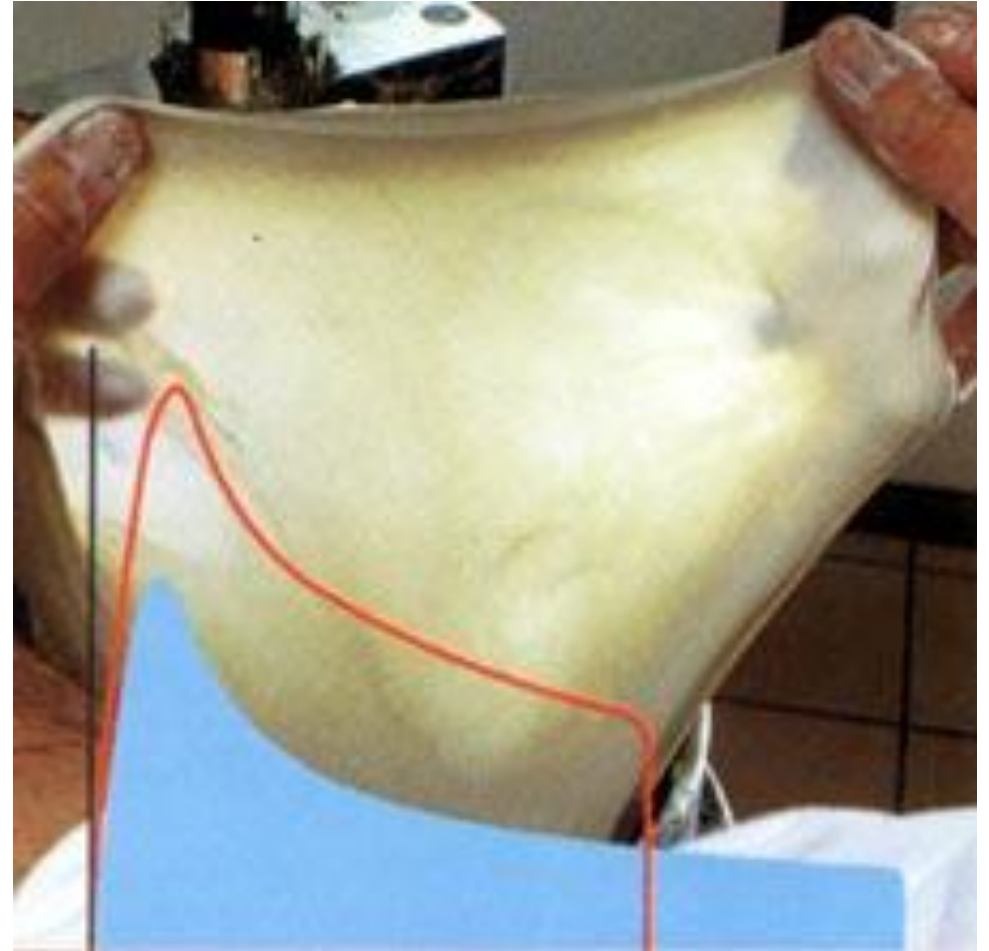
Baking strength, W

Baking strength depends on:

- Protein quantity and quality,
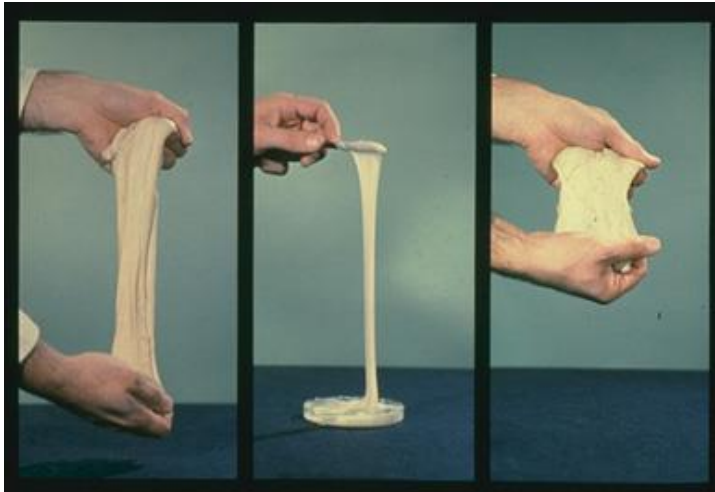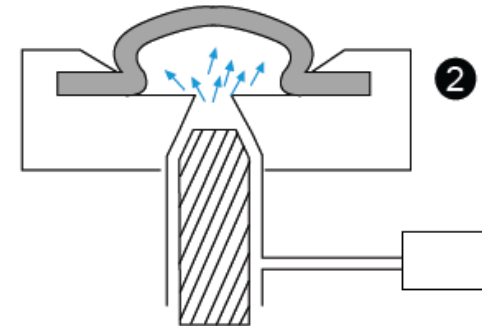- Starch damage,
- Enzymes,
- Interactions...

W is one of the industrially most applied alveograph parameters, as it is used for prediction of processing behavior of flours.

→ **W is a global value (Energy).**

Tenacity, P

➤ The parameter P is the maximum overpressure needed to inflate the dough bubble. The parameter is also called the dough tenacity.

➤ P is one of the most used alveograph parameters.

➤ It is the indicator of dough resistance to deformation, but it has also been claimed that it is an indicator of dough tensile strength in the initial stage of deformation, related to the stiffness, shortness and tightness of the dough, an indicator of dough stability.

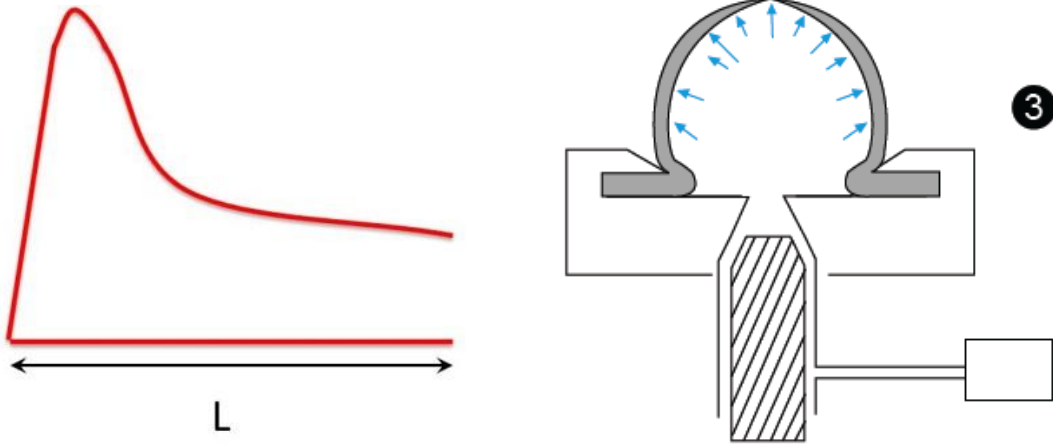# Tenacity, P
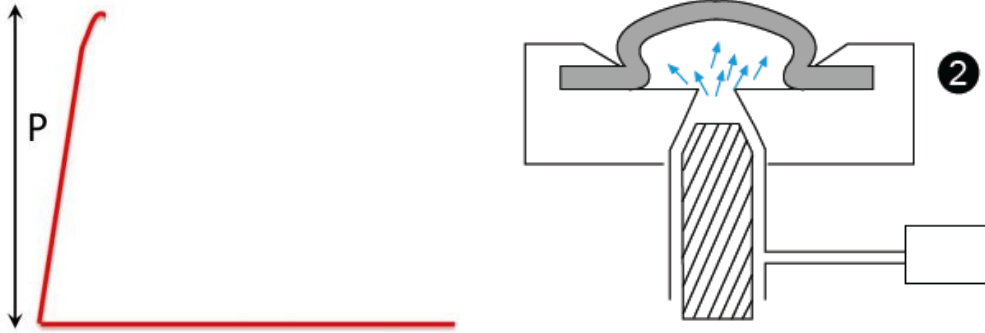
Tenacity depends on water absorption capacity:

- Protein quantity and quality,
- Starch damage,
- Fibers (pentosans, ash content)

→ **For a given hydration, "tenacity" represents the dough consistency (how hard a dough is).**
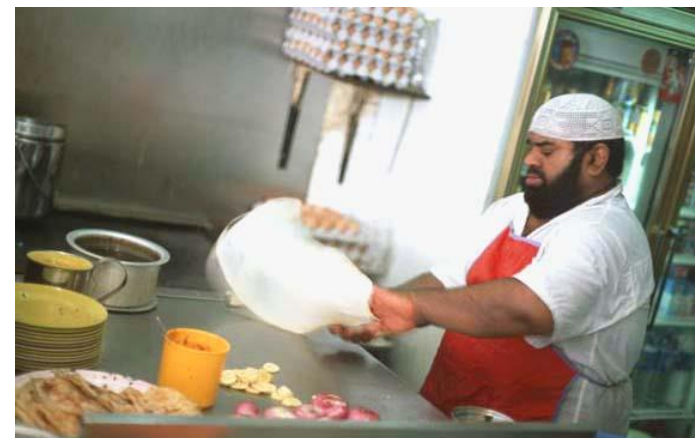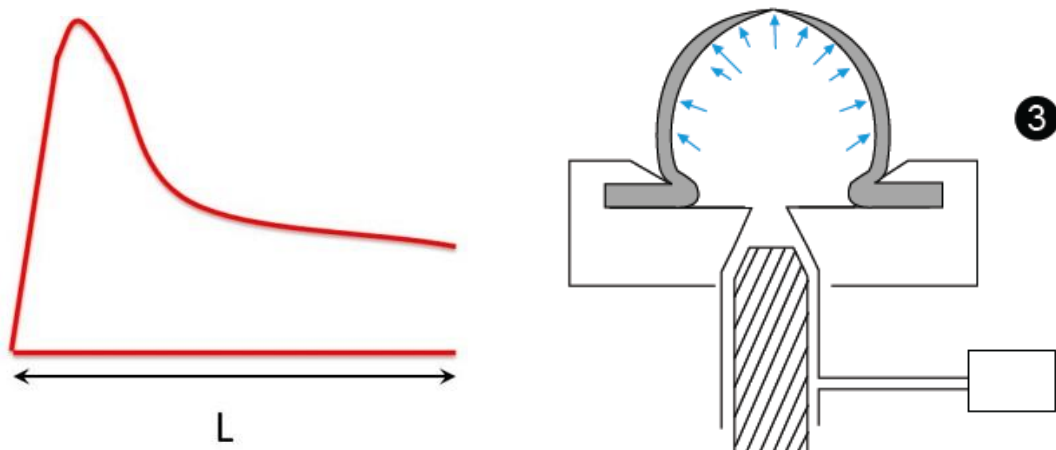
Extensibility, L or G

➢ L (average abscissa to rupture), it is a measure of how much the dough can be extended before it breaks.

➢ L has strong, positive correlations with several bread properties, including bread volume!

➢ G (swelling index) is related to the spring and the shortness of the dough!

# Extensibility, L or G

Extensibility depends on:

- Protein quantity and quality (mainly).

→ **Extensibility represents the dough potential to stretch to hold gas** (gas retention capacity)

Elasticity, I.e.

➢ **Elasticity represents the capacity of a dough to stretch and return to its initial position** when stress ends.

➢ It is measured **40 mm after the beginning of the curve** (L = 40)

➢ The bubble volume at this instant indicates the dough resistance to deformation. **It is a way to evaluate the elasticity.**

P =100

$Ie = (P_{200}/P)*100$

$Ie = (45/100)*100$

$Ie = 45\%$

P_{200}

45
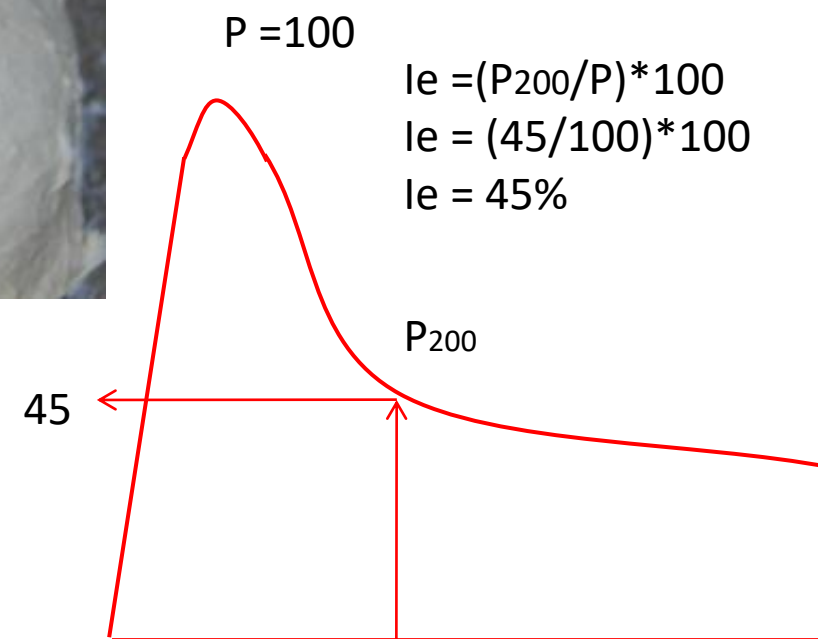
Elasticity, I.e.

➢ I.e. has been found to be affected by different flour constituents as well as addition of different ingredients. The elasticity index of a flour needs to be within a certain range, dependent on the type of product.

➢ Too high and low values of I.e. are not desirable, as e.g. doughs with high I.e. tend to be hard to elongate and shrinks.

➢ Comparisons of I.e. and bread properties are limited in the literature, but a significant, positive correlations ($p < 0.05$) between I.e. and bread volume and the height/width ratio for rolls have been found!
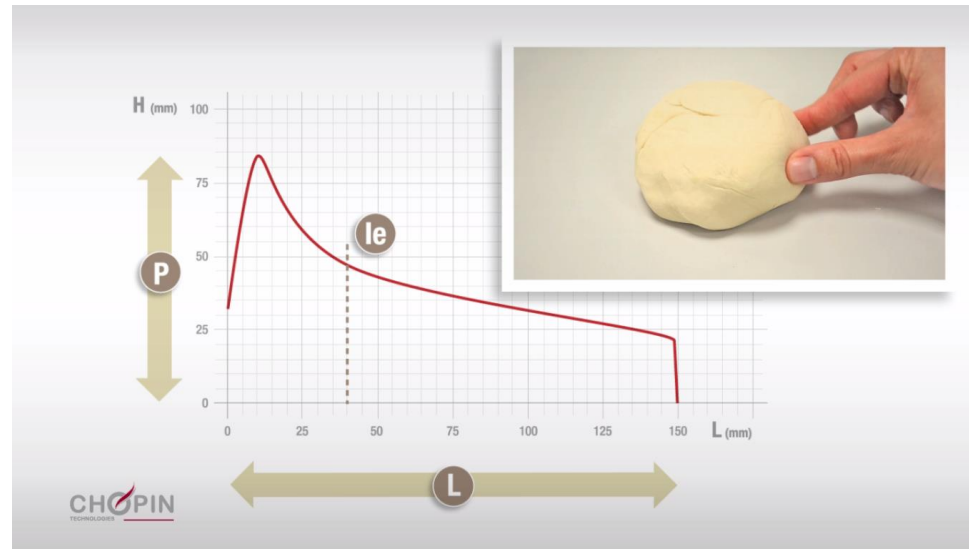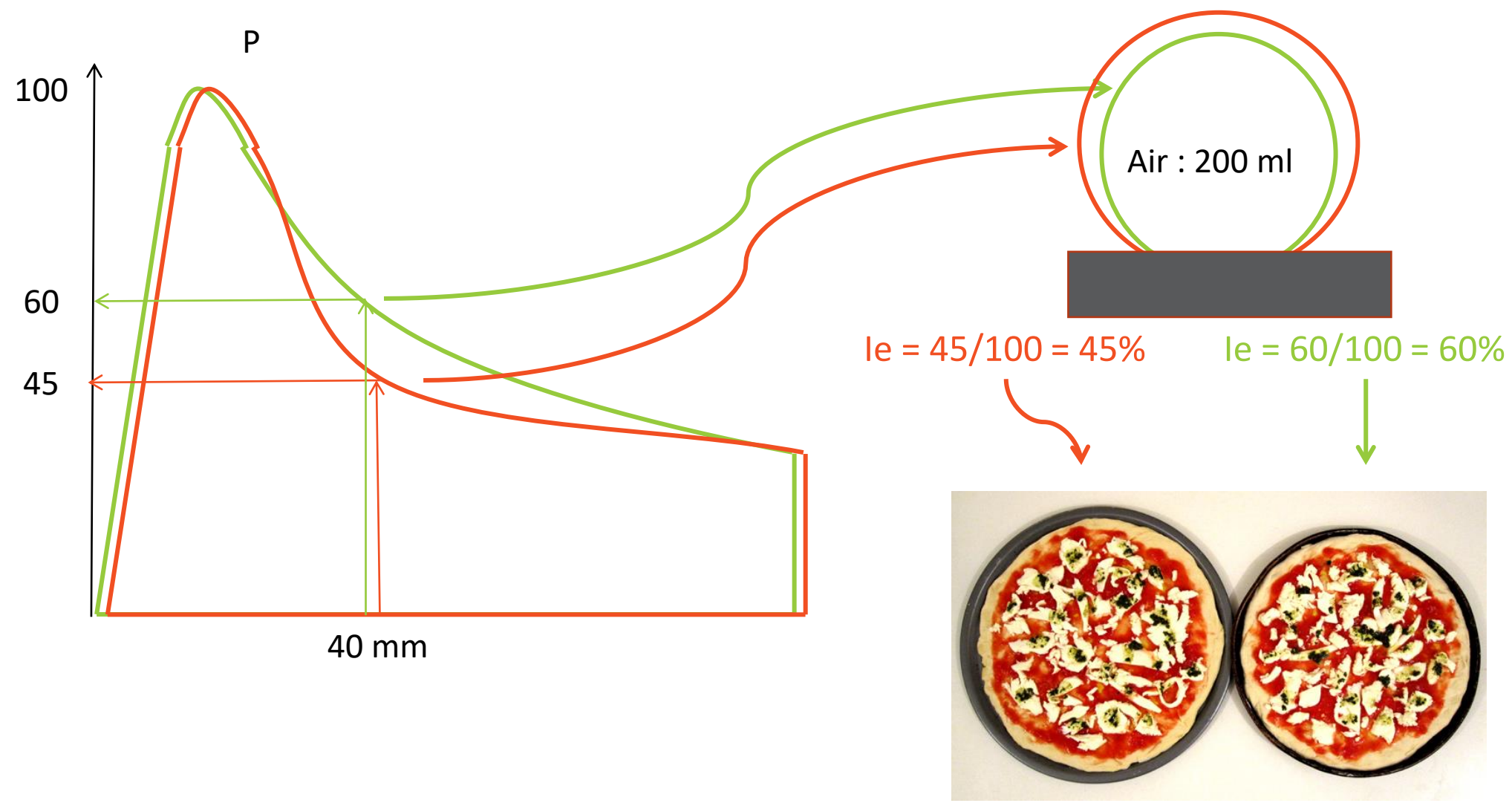
Focus on elasticity measurement

Ie = 45/100 = 45%   Ie = 60/100 = 60%

Figure given as example. Do not correspond to real values

Curve configuration ratio, P/L

➢ Configuration ratio value combines the readings of tenacity and dough extensibility.

➢ It is the balance between dough strength and extensibility.

➢ High **P/L** indicates a resistant and inextensible dough, while low P/L indicates a weak and extensible dough!
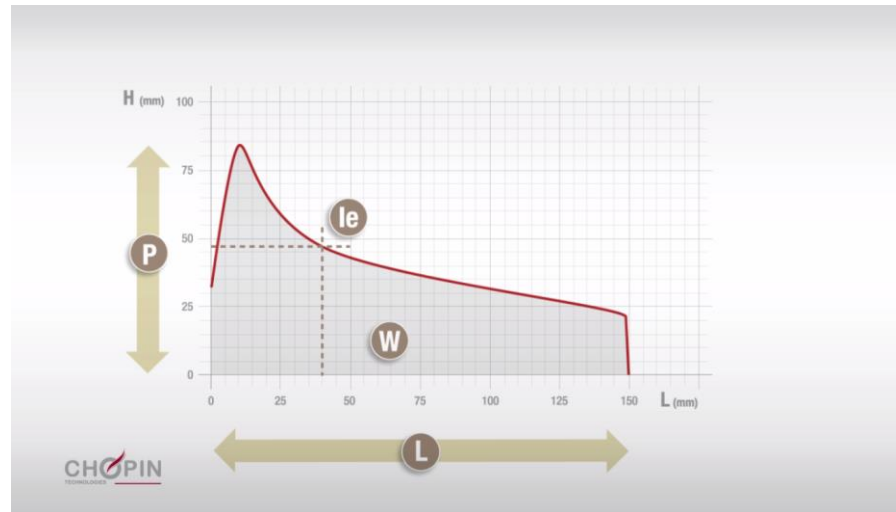
Why is Alveograph important?

> ➢ The Alveograph test provides results that are common specifications used by flour millers and processors to ensure a more consistent process and product.

- Weak gluten flour with low P value (strength of gluten) and long L value (extensibility) is preferred for cakes and other confectionary products!

- Strong gluten flour will have high P values and is preferred for breads!

Why Alveograph differs from other instruments used for stretchability tests?

➤ Unlike other instruments that stretch the dough piece in a simple (uniaxial) mode, alveograph expands the dough in all directions (biaxial extension)!

From a physical point of view, biaxial extension equates well with the gas cell expansion in a rising dough.

Alveograph resembles deformations that take place during fermentation or oven rise!
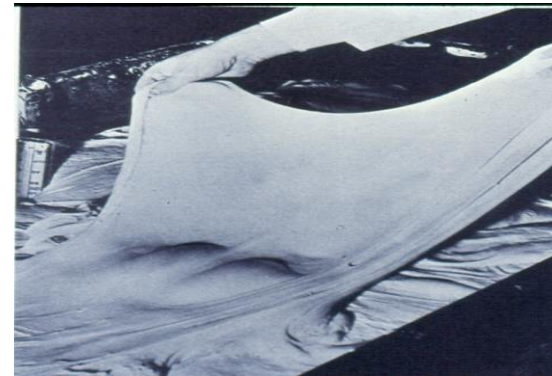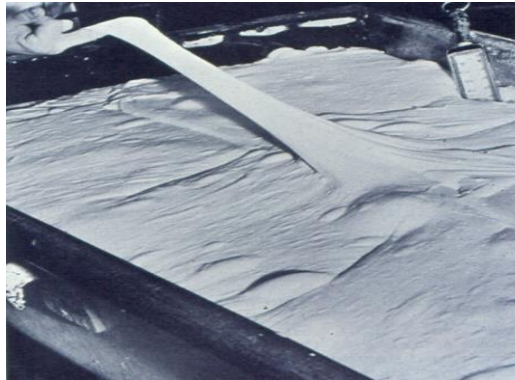
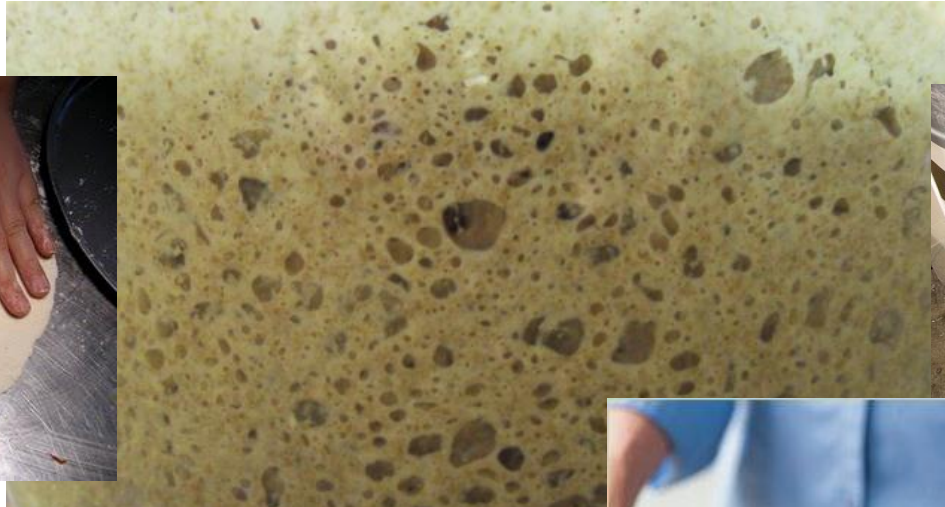# Why Alveograph differs from other instruments used for stretchability tests?

➢ Other instruments stretch the dough at a constant rate, which is essentially independent of the resistance of the dough to stretching. In contrast, the rate at which the dough bubble expands during the alveograph test changes with the volume of the bubble!
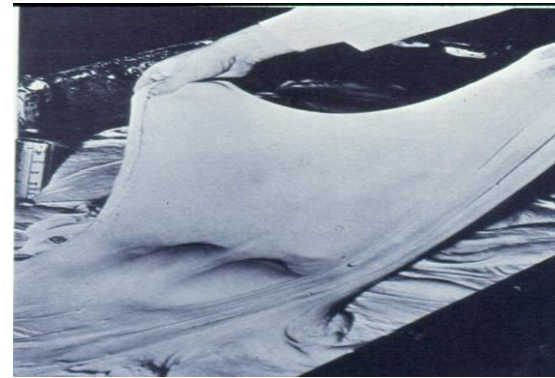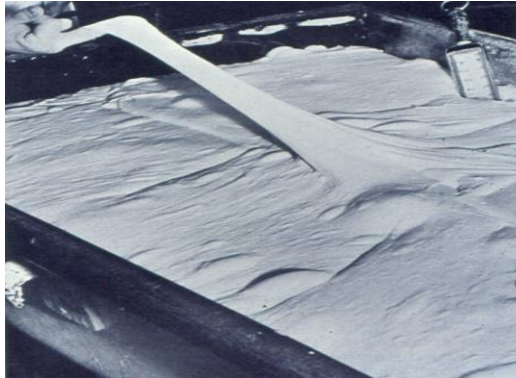
Is baking using ?

- 3D ?
- Uniaxial ?

Chopin Alveograph
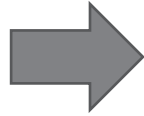
Main Applications

KPM

Alveograph: From Farm to Table

BREEDERS

- Characterizing wheat
- Detect insect contaminated wheat

MILLERS

- Characterizing wheat and flour according to their application
- Detect insect contaminated wheat
- Analysis of different flour mill streams
- Wheat or flour blending
- Measuring the impact of additives
- Assessing the impact of damaged starch
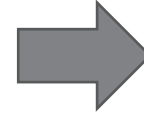
SECONDARY PROCESSING INDUSTRIES

- Determine specifications for the flour received (R&D)
- Verifying the conformity of delivered flours (QA)
- Measuring the impact of additives

KPM

Alveograph for millers

- ✓ Alveograph analysis is an established method for flour characterization, and several alveograph parameters have been introduced over the years.

- ✓ The alveograph is an empirical tool used to assess the baking quality of wheat flour.

- ✓ The results from the alveograph is widely used for commercial benchmarking of wheat flour and decision making.

Classify wheats with the Alveograph

W 70
M. HUNTSMAN

W 160
FRENCH WHEAT

W 45
CLEMENT

W 300
BAHIA

W 435
CWRS

W 365
DNS

W 105
US SOFT WHEAT
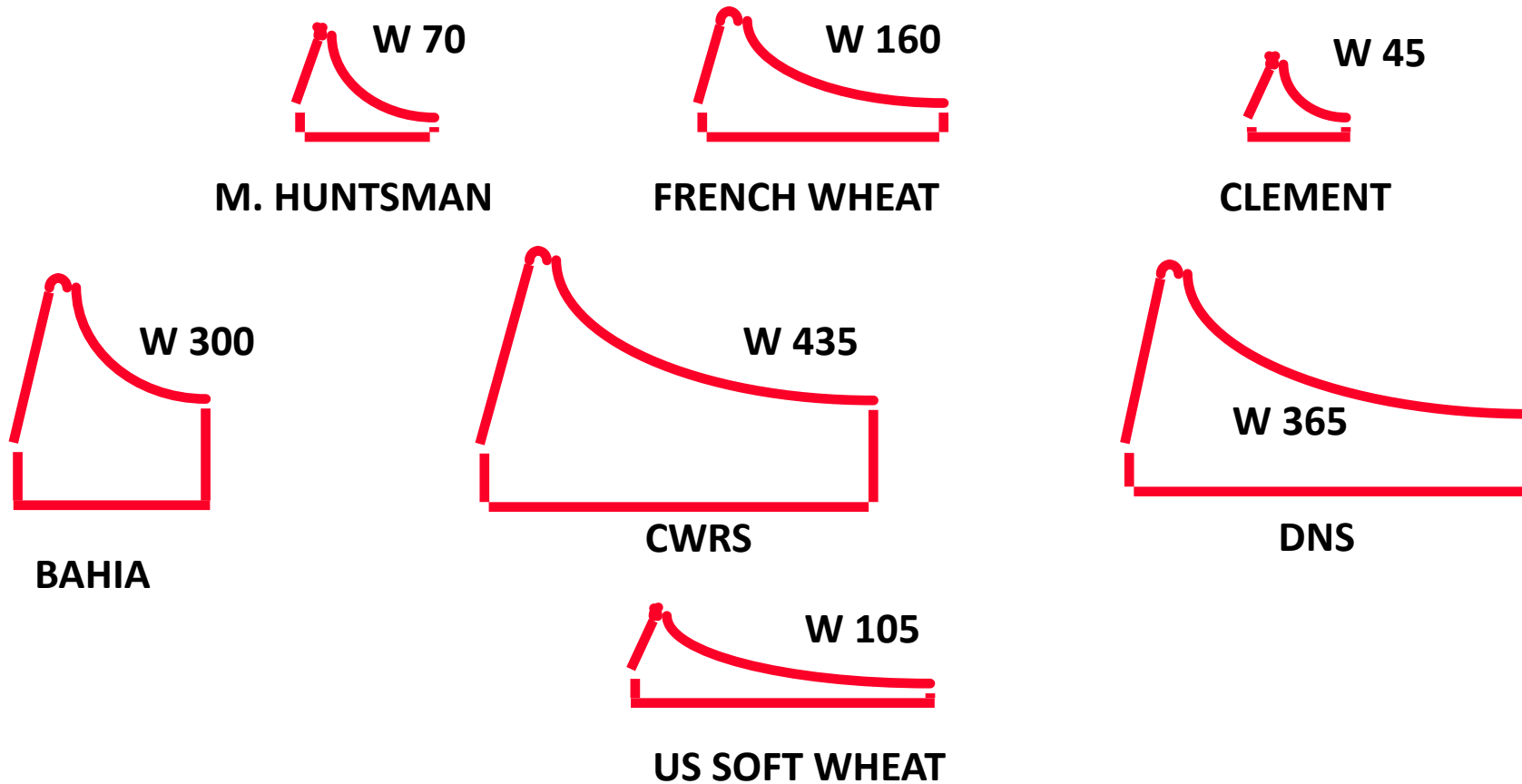
Classify/Evaluate flours with the Alveograph

Michel Dubois, 1988

W

| WEAK 100 W | MEDIUM 170 W | STRONG >250 W |

| P : 40 G : 21 → WAFERS | P : 50 G : 22,5 → COOKIES | P : 55 G : 24 → CRACKERS | P : 62 G : 22 → FRENCH BREAD | P : 70 G : 22,5 → CROISSANTS | P :80 G : 24 → HAMB. BUNS |

Blend wheats or flours

50 %

W =96

G = 19.4   P = 46

+

50 %

W = 224

G = 17.5   P = 103

=

100 %

W = 160

G = 18.5   P = 74
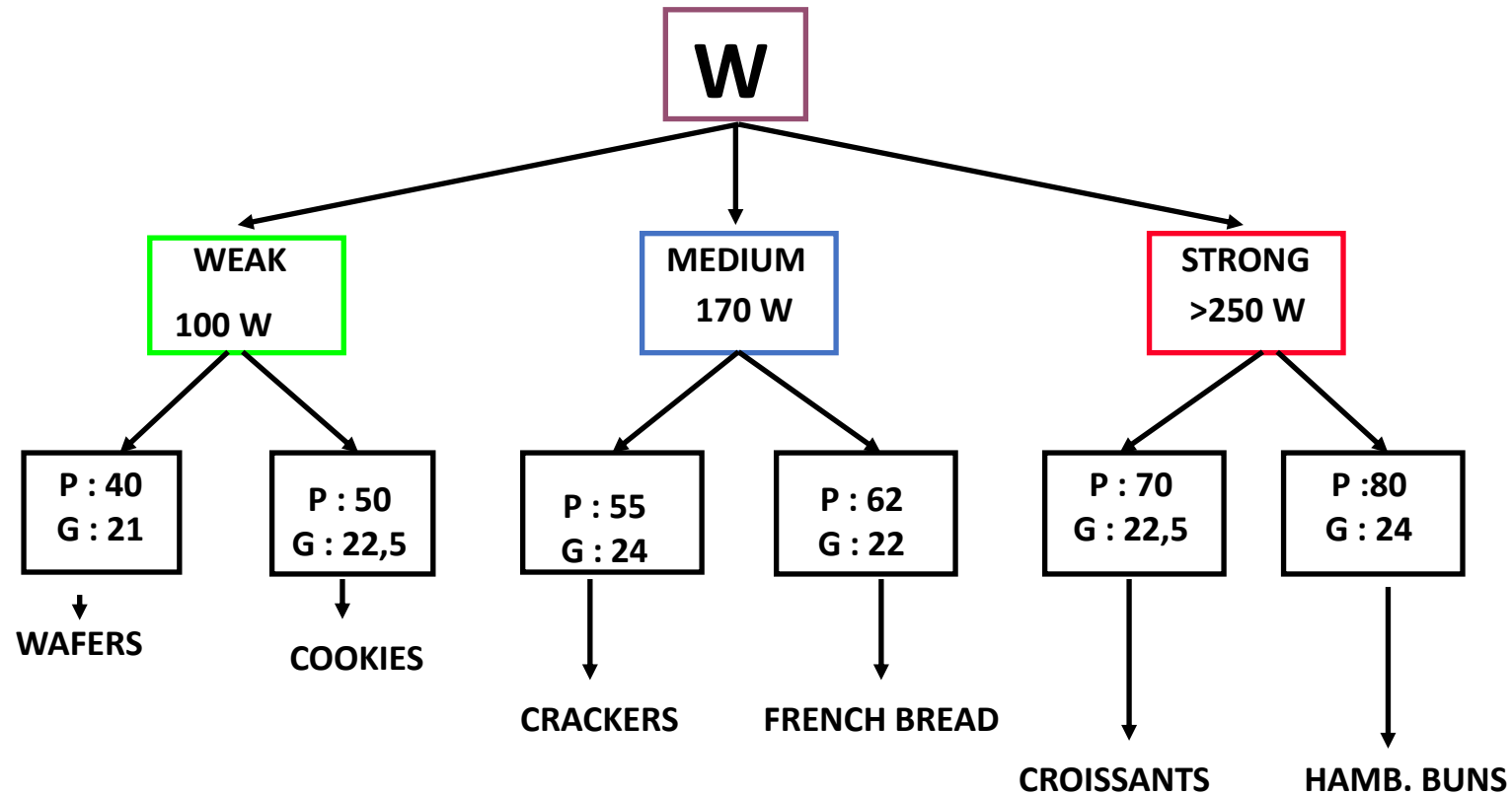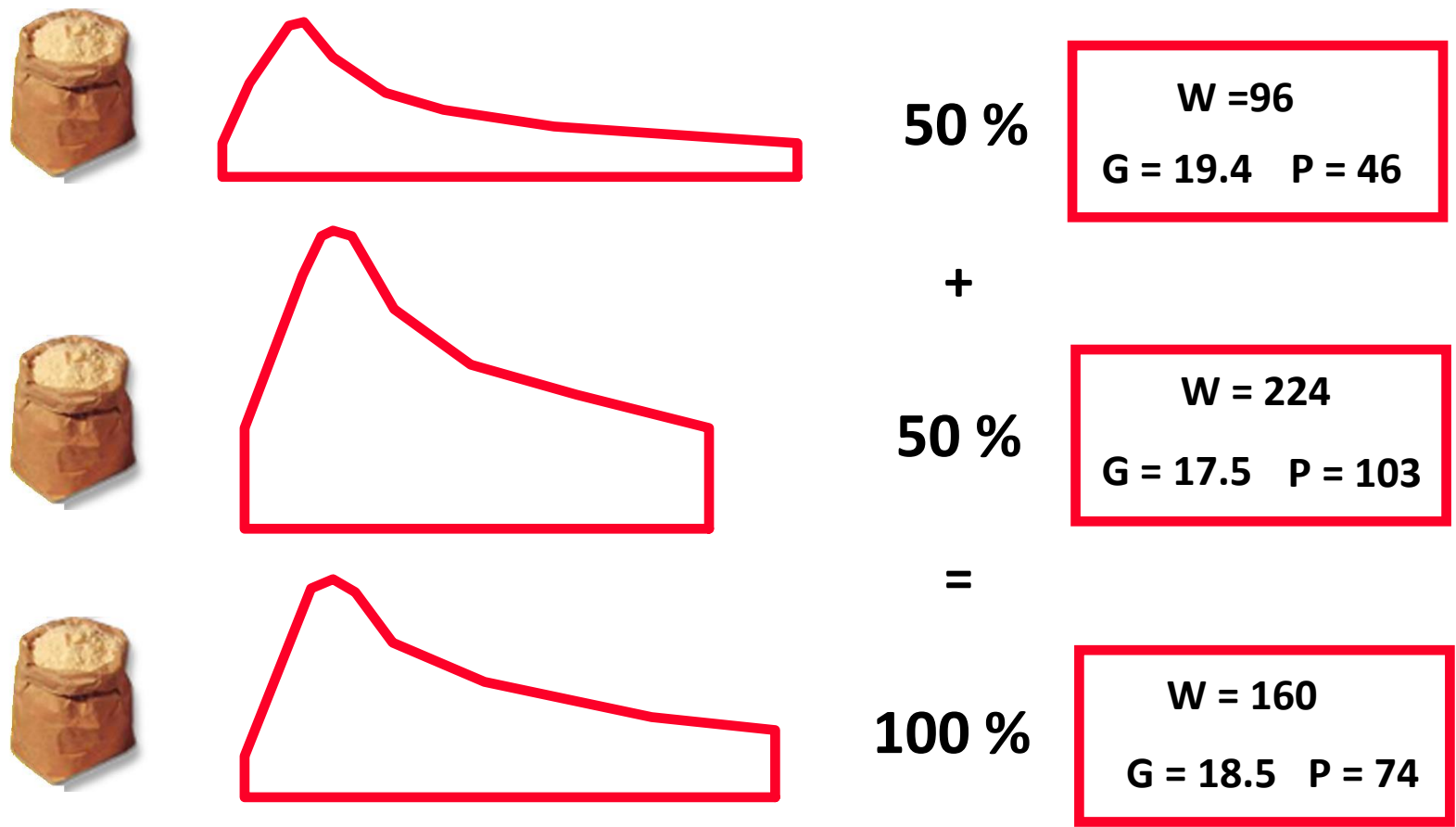
Protein quantity is not protein quality!

| Hard White	Pacific Northwest		California	Southern Plains			Northern Plains	
	Low	Very High	High	Low	Medium	High	High	Very High
Wheat Grade Data:								
Test Weight (lb/bu)	61.4	60.9	63.8	61.6	62.6	62.5	62.3	62.3
(kg/hl)	80.7	80.1	83.8	81.0	82.3	82.2	81.9	81.9
Damaged Kernels (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Foreign Material (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Shrunken & Broken (%)	1.6	1.9	0.5	0.8	0.7	1.3	0.5	0.5
Total Defects (%)	1.6	1.9	0.5	0.8	0.7	1.3	0.7	0.5
Grade	1 HW	1 HW	1 HW	1 HW	1 HW	1 HW	1 HW	1 HW
Wheat Non-Grade Data:								
Dockage (%)	1.0	0.5	0.0	0.9	0.8	0.5	0.2	0.1
Moisture (%)	9.1	9.8	7.8	10.8	10.4	11.2	9.6	10.2
Protein (%) 12%/0% moisture basis	11.1/12.6	13.9/15.8	12.7/14.4	10.9/12.4	12.4/14.1	13.1/14.9	13.2/15.0	13.9/15.8
Ash (%) 14%/0% moisture basis	1.41/1.64	1.51/1.76	1.37/1.59	1.40/1.63	1.36/1.58	1.55/1.80	1.63/1.90	1.43/1.66
Dough Properties:								
Farinograph:								
Peak Time (min)	7.4	7.8	5.8	2.7	7.0	5.8	6.9	7.3
Stability (min)	22.2	16.2	9.0	8.7	13.7	11.4	14.4	19.1
Absorption (%)	55.5	61.1	60.3	54.2	57.7	58.8	56.4	58.7
Alveograph: P (mm)	75	81	73	52	68	61	59	67
L (mm)	154	202	198	154	164	203	203	202
P/L Ratio	0.49	0.40	0.37	0.34	0.41	0.30	0.29	0.33
W (10-4 joules)	358	432	337	222	307	329	384	398
Extensograph: Resistance (BU)	461/653	536/888	421/927	315/351	350/728	420/648	627/806	476/887
(45/135 min) Extensibility (cm)	21.8/17.4	23.7/17.4	22.0/15.4	19.2/17.9	16.0/12.9	20.2/18.3	19.3/17.1	22.1/14.7
Area (sq cm)	137/145	162/188	112/173	85/83	69/115	105/147	134/159	129/153
Baking Evaluation:								

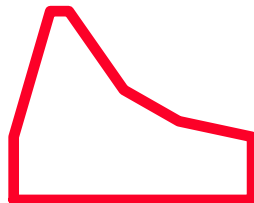# Check production regularity

Constant
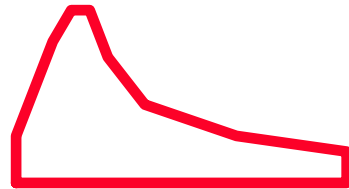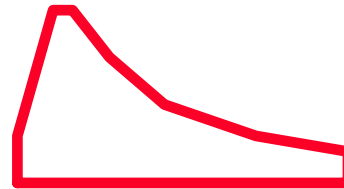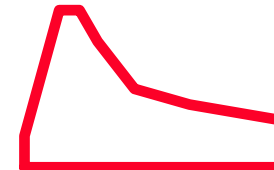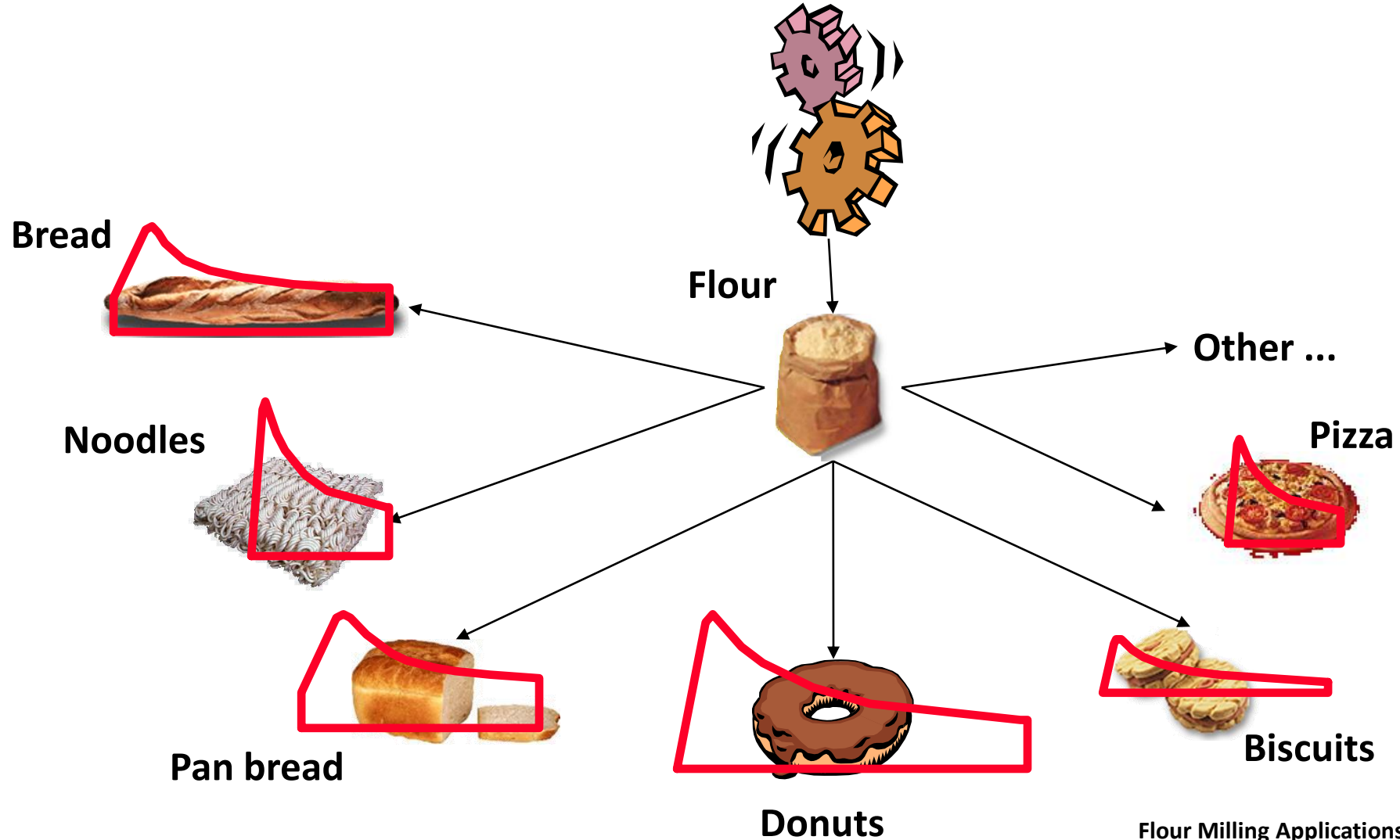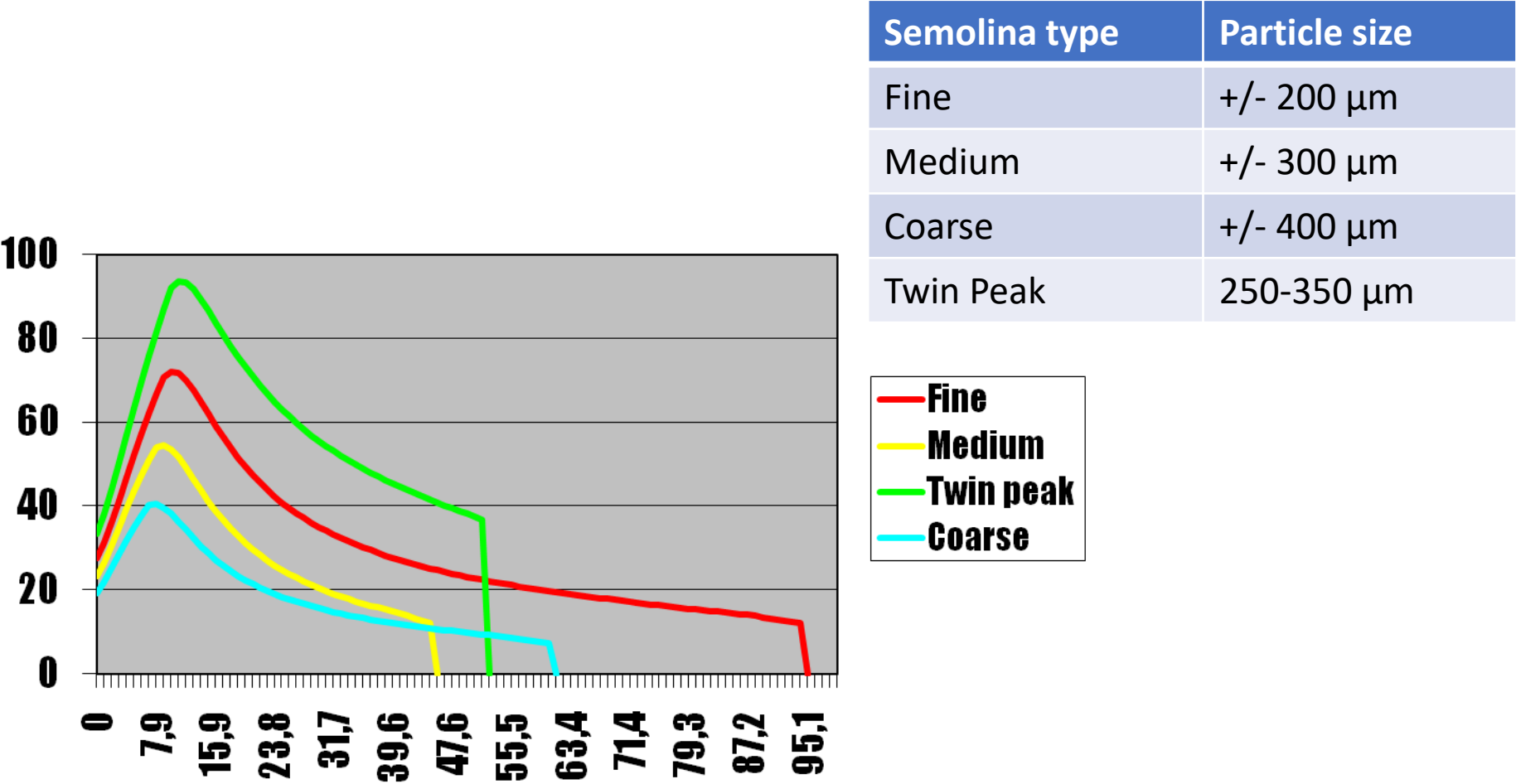
Monday   Tuesday   Wednesday
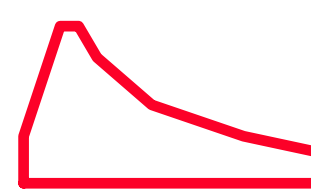
Not constant

Monday   Tuesday   Wednesday

Make flours adapted to their application
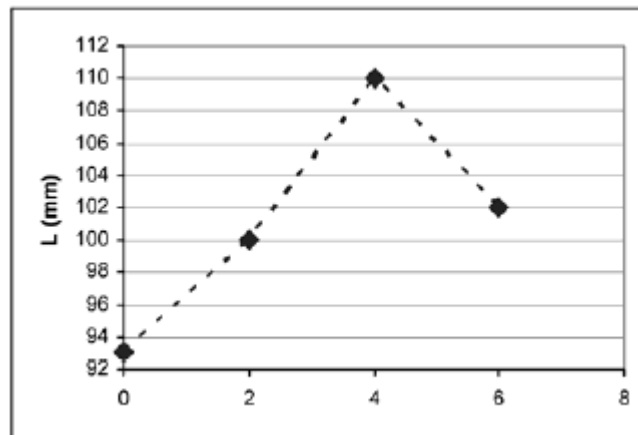

Bread

Flour

Other …

Noodles

Pizza

Pan bread

Donuts

Biscuits

Durum wheat protocol *(Triticum Durum)*

Semolina type	Particle size
Fine	+/- 200 µm
Medium	+/- 300 µm
Coarse	+/- 400 µm
Twin Peak	250-350 µm

Effects of Additives: Vital Wheat Gluten

3 % GLUTEN

2 % GLUTEN

1 % GLUTEN

INITIAL FLOUR
0 % GLUTEN

Effects of Additives: Ascorbic acid

2 g

1.5 g

1.0 g

0.5 g

REF FLOUR
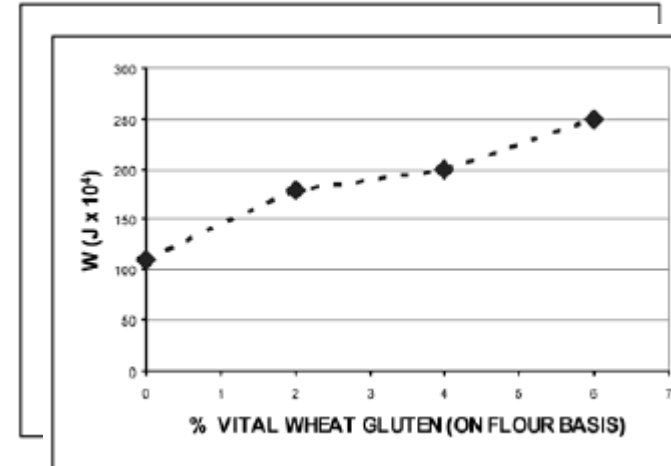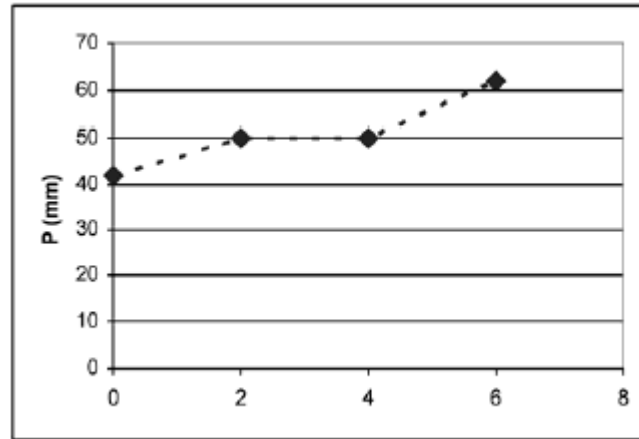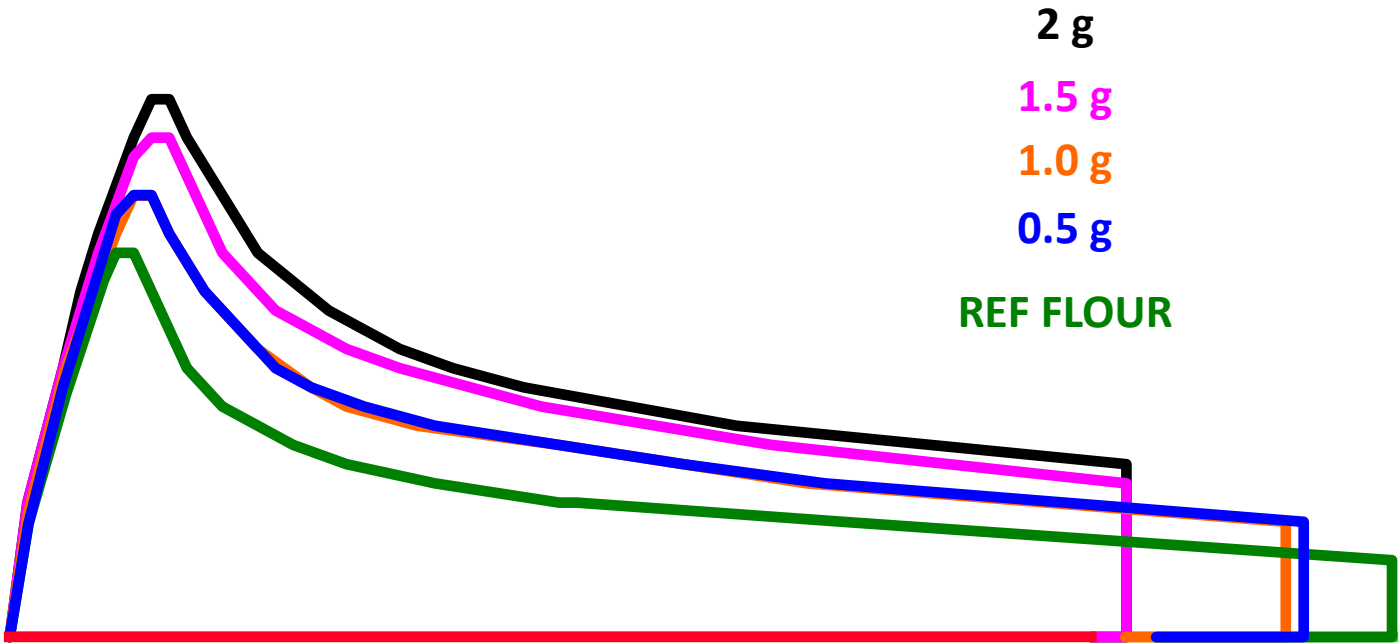
Effects of Additives: Ascorbic acid
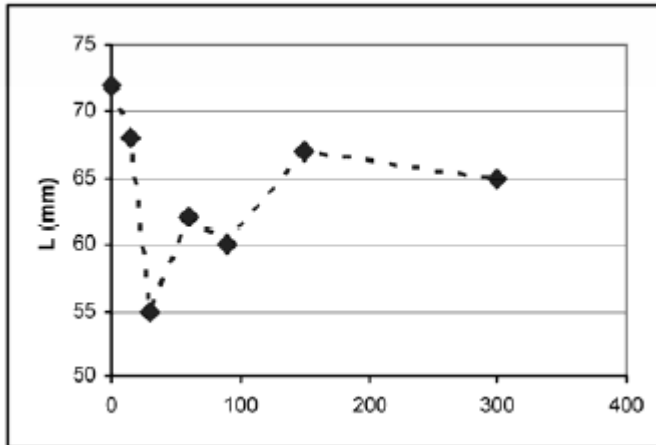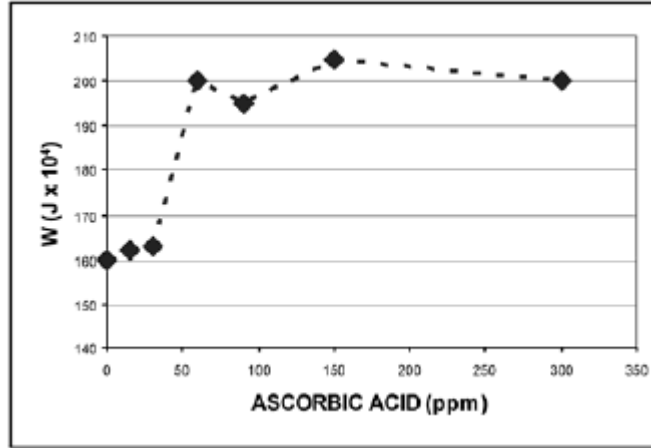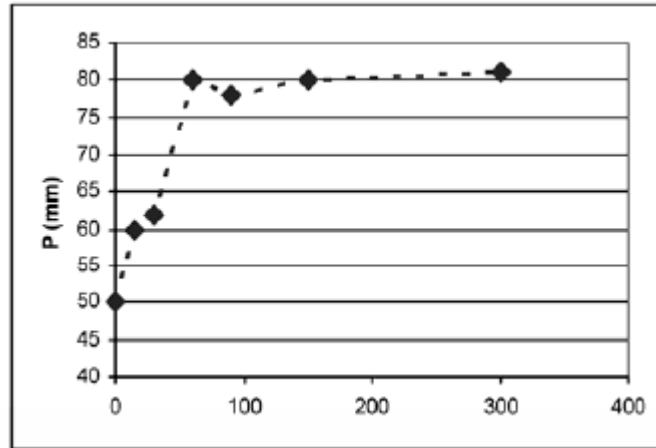
Effects of some additives on the Alveograph curve

Name	Effect on P	Effect on W	Effect on L
Amylases	-	-	+
Amylase-hemicellulase complexes	-	-	+
Beta-amylase	-	-	+
Glucoamylase	-	-	+
Glucose oxidase	+	-	-
Proteases	-	-	+
Lipase	+	+	-
Hemicellulase	=	+	+
Ascorbic acid	+	+	-
Potassium bromate	+	+	-
Calcium peroxyde	+	-	-
Lecithin-based emulsifiers	+	+	+
DATEM-based emulsifiers	-	+	+
Malt	-	-	+
Malted barley	-	-	+
Vital wheat gluten	+	+	=
Azodicarbonamid	+	=	-
Sodium metabisulfite	-	-	-
Cysteine	-	-	+
Acidity regulators	+	+	+
Inactivated Yeast	-	-	=

Mixer 26 °C   Resting 28 °C   Alveo 25 °C   Hygrometry : 20 %
Water 24 °C   Water level :   Mixer door :   Alveo door :

Since 2016 : Two versions available
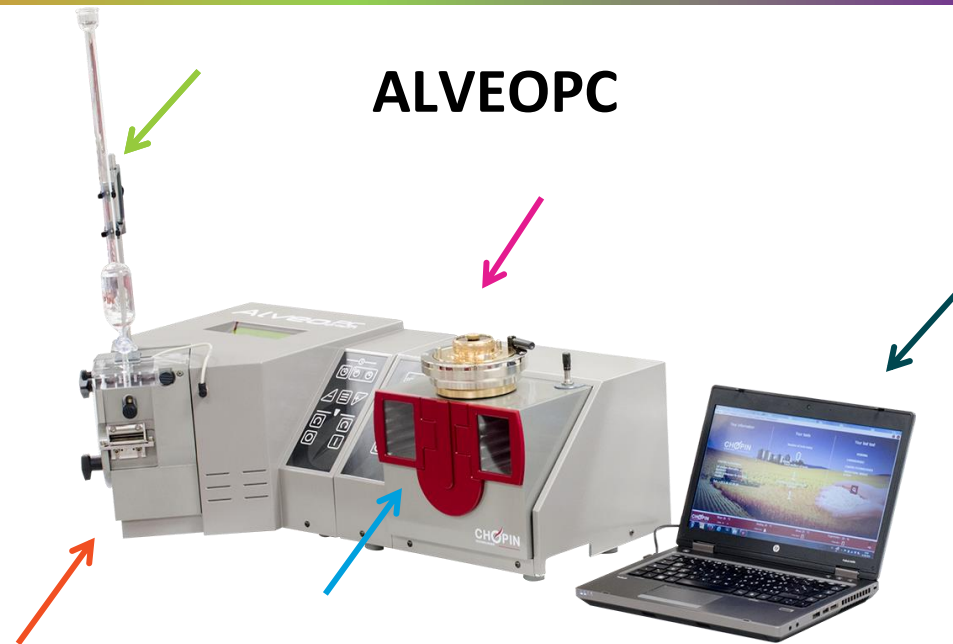
ALVEOPC

Mixer bowl
Auto water system
Resting chamber
Test platin
Recording system

The Alveolab is an easier, more versatile version !

The Alveolab is EASIER !

Easy installation:

- No cooling system required
- Just need a 220V outlet

Automatic water injection:

- Precise dosage (+/- 0.05ml)
- No operator impact

→ Improved precision and time saving
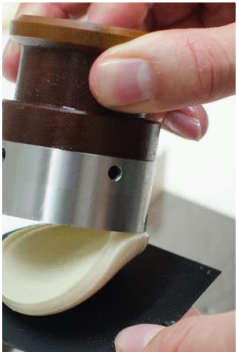
Improved preparation of the patties:

- Semi-automatic cutter
- Anti-adhesive resting plates
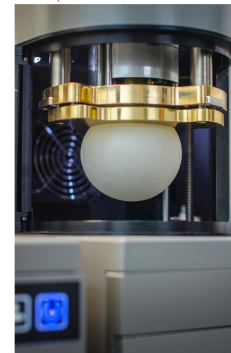
Blowing bubbles has never been easier:

- Automatic flattening of the patties
- Temperature and hygrometry controlled.

→ No impact of the lab conditions

The AlveoLab brings out new possibilities !
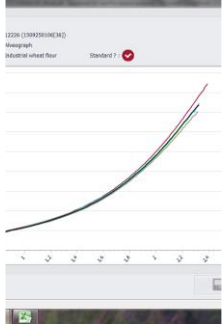
New results available

→ Get more information at the same time!

Endless possibilities for protocol adaptation

→ Improved versatility

Complete and intuitive software !

→ More tools available

Getting the most out of the Alveograph's test
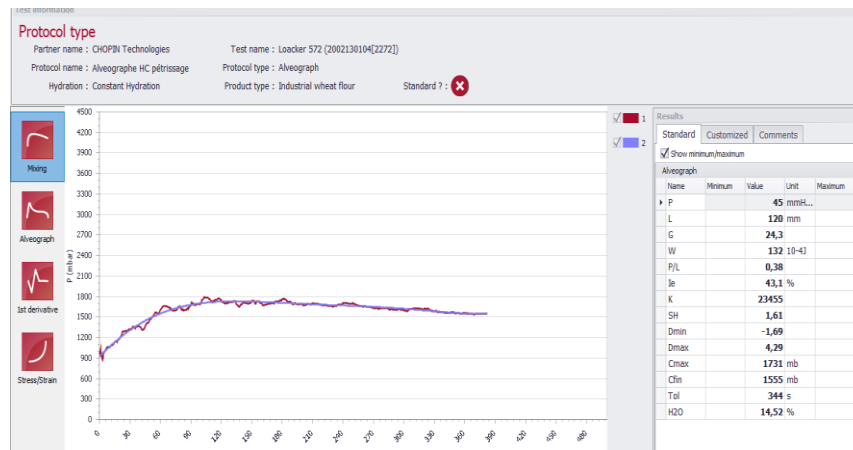
CONSISTENCY RECORDED DURING MIXING
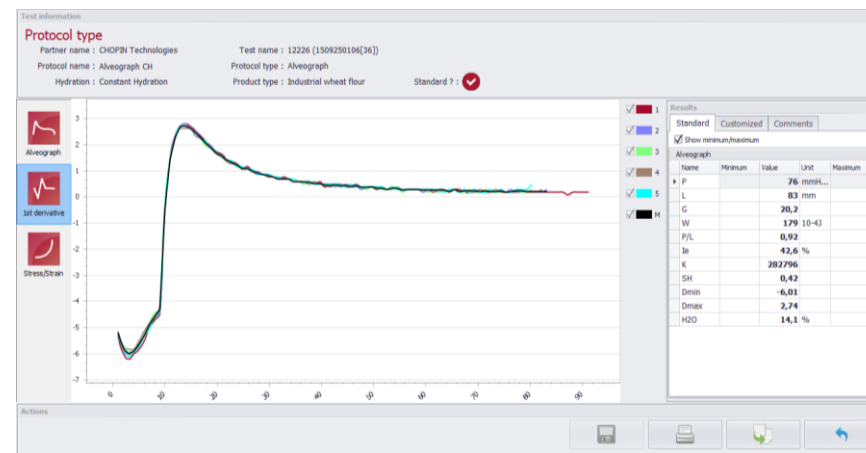
FIRST DERIVATIVE

STRESS/STRAIN

Minimum of first derivative, Dmin.

Maximum of first derivative, Dmax.

Strain hardening index, SH.

Strength coefficient, K.

Intuitive and complete software

Blending law

Improver guide

Automatic control charts

Online assistance via Teamviewer
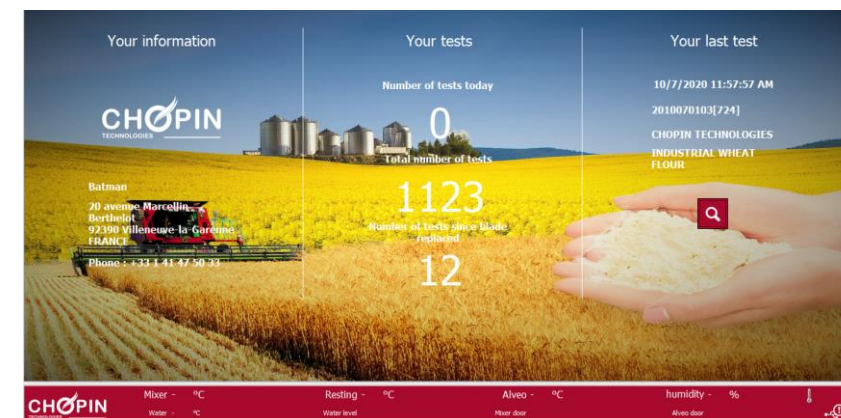
NEW opportunities to analyze wheat flour

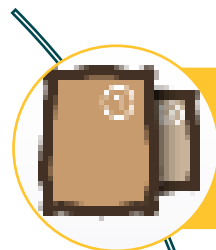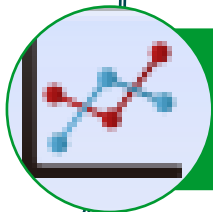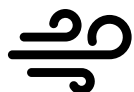|	You can play with:	Parameter	Minimum	CHOPIN standard	Maximum
TEMPERATURES		Water temperature	15°C	20°C	22°C
		Mixer temperature	18°C	24°C	35°C
SPEEDS		Mixing speed	30 rpm	60rpm	100 rpm
		Mixing time before cleaning	0.5 min	1 min	3 min
		Cleaning time	0 min	1 min	3 min
TIMES		Mixing time after cleaning	0 min	6 min	60 min
		Resting time during mixing	0 min	0 min	60 min
		Mixing time after resting	0 min	0 min	60 min
SAMPLES		Number of patties	1	5	6
		Resting temperature	18 °C	25°C	35°C
		End of resting time from end of mixing	0 min	28 min	300 min
		Alveo analysis chamber temperature	18°C	20°C	30°C
HYGROMETRY		Alveo analysis chamber relative humidity	30%	65%	90%
		Air flow	40 L/h	96 L/h	110 L/h
AIR FLOW		Air insufflation Time	4 s or 4 ml	-	50 s or 33000 ml
		Acquisition time	30 s	-	3600 s

KPM

Focus on Alveograph test at adapted hydration

The Alveograph is perfectly suited for strong hard wheats!

Adapted hydration protocol Available since 1998

The AlveoConsistograph Handbook — Second Edition — Michel Dubois, Arnaud Dubat, and Bernard Launay
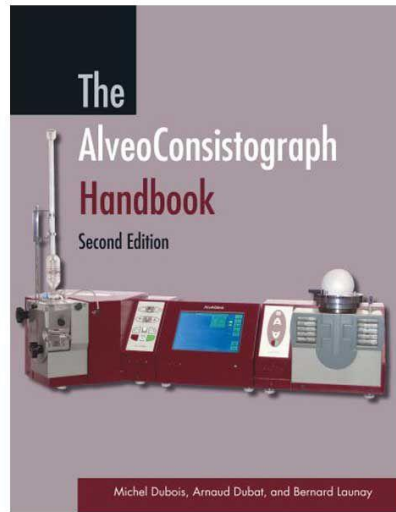
- Hydration determined thanks to the **Consistograph**
- Test is about 5 minutes
- Obtained results are indicated with an "HA" index
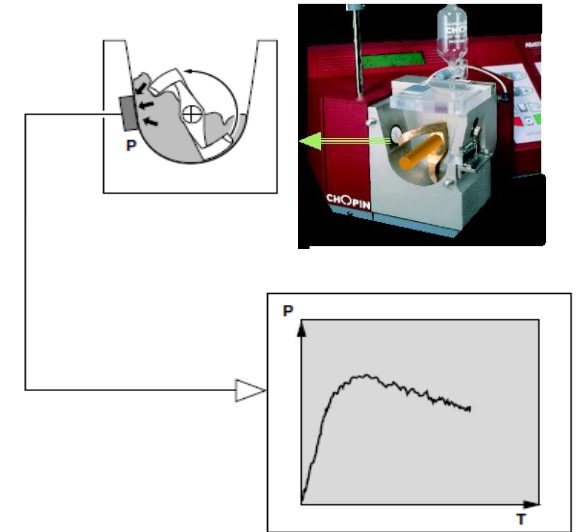
Now Standardized !
ICC 188

KPM

AlveoPC or Alveolab?

AlveoPC

AlveoLab

Dimensions

Price

No need for a controlled environment, no cooling system..

More data from one single test

Adaptability (more protocols : AH, whole meal flour...)

Easier to use (automatic water injection, positioning and squashing of test dough pieces...)

See detailed list :

Compare and choose the Alveograph that best suits your needs

For more information: www.chopin.fr/en or info@chopin.fr

CONCLUSION

The Alveograph instruments in a nutshell

- Measure key dough properties (P, L, Ie, W)
- Get access to more information from tour test
  - Strain hardening, mixing properties...

Aim

- Deformation of a dough patty in three dimensions (Bubble)

Principle

- 35 minutes and 250 grams of flour for standard test.
- 45 minutes and 500 grams of flour for adapted hydration

Analysis time & sample size

- Internationally recognized
- Precision
- Full information
- Service & support
- More complete information

Benefits

- Only instrument allowing to measure dough properties submitted to 3D deformation (bubble blowing).
- Complete software solution

Unique features

- ISO 27971 including possibility to test Grain
- ICC 54-30.02
- ICC 121
- ICC 188
- ...

Standards

Key:
AlveoLab Only

KPM

KPM Analytics Introduction

Global Leader in Analytical Instrumentation

KPM Analytics enables food producers to effectively manage product quality and protect the value of their brands

Our Brands

Industries

Agriculture

Food & Beverage

Feed & Forage

Environmental

Clinical

Industrial
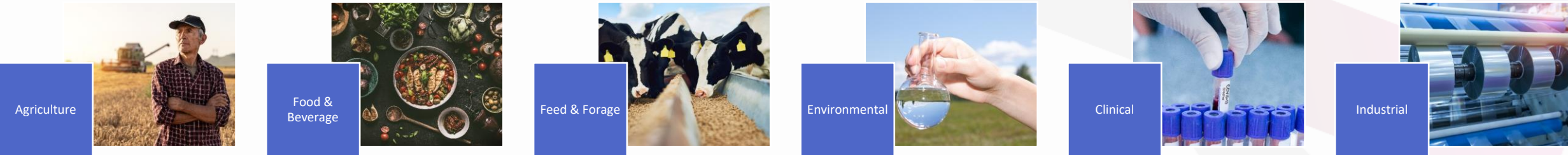
Impacting Quality Across the Entire Value Chain

Measuring quality at **every** step for ingredients, food, and feed customers.

QUALITY ASSURANCE

FARM · INSPECT · PROCESS · FINISHED PRODUCT · CONSUMER

SPECIFY · INSPECT · MONITOR · CONTROL · ANALYZE

RESEARCH & DEVELOPMENT

- KPM Analytics provides critical insight and analysis for companies to achieve the highest quality standards at every step of their process

- Our solutions provide rapid, precise, and repeatable data that directly impacts business results

- We help food producers reduce waste and costs, increase energy efficiency, improve quality, and protect their brands

Timeline and Growth of KPM Analytics

2015

Union Park Forms
KPM Analytics

- **Acquires Unity Scientific**
- Founded in **2001**
- Based in Brookfield, CT
- NIR Analyzers used in food/feed/forage

Acquires CHOPIN Technologies
- Founded in **1920**
- Based in Paris, France
- Serving flour, grain and dough producers
- Composition analysis and functional testing

2016

- **Acquires Process Sensors**
- Founded in **1996**
- Based in Milford, MA
- On-line moisture gauges
- NIR technology

2017

Acquires AMS Alliance
- Founded in **1988**
- Based in Rome, Italy
- Serving clinical, environmental, and food/beverage
- Automated wet chemistry analysis

Acquires Sensortech Systems
- Founded in **1983**
- Based in Oxnard, CA
- NIR and RF on-line moisture measurements

Acquires Sightline Process Control
- Founded in **2009**
- Based in Ottawa, Canada
- 3D/color vision inspection systems

2019

2021

Acquires EyePro System
- Founded in **1999**
- Based in Trento, Italy
- Baking and snack food industry
- Vision inspection systems

Acquires Bruins Instruments
- Founded in **1979**
- Based in Puchheim, Germany
- NIR Analyzers used in grain/meat

2022

KPM Analytics brands have long and successful histories servicing customers worldwide

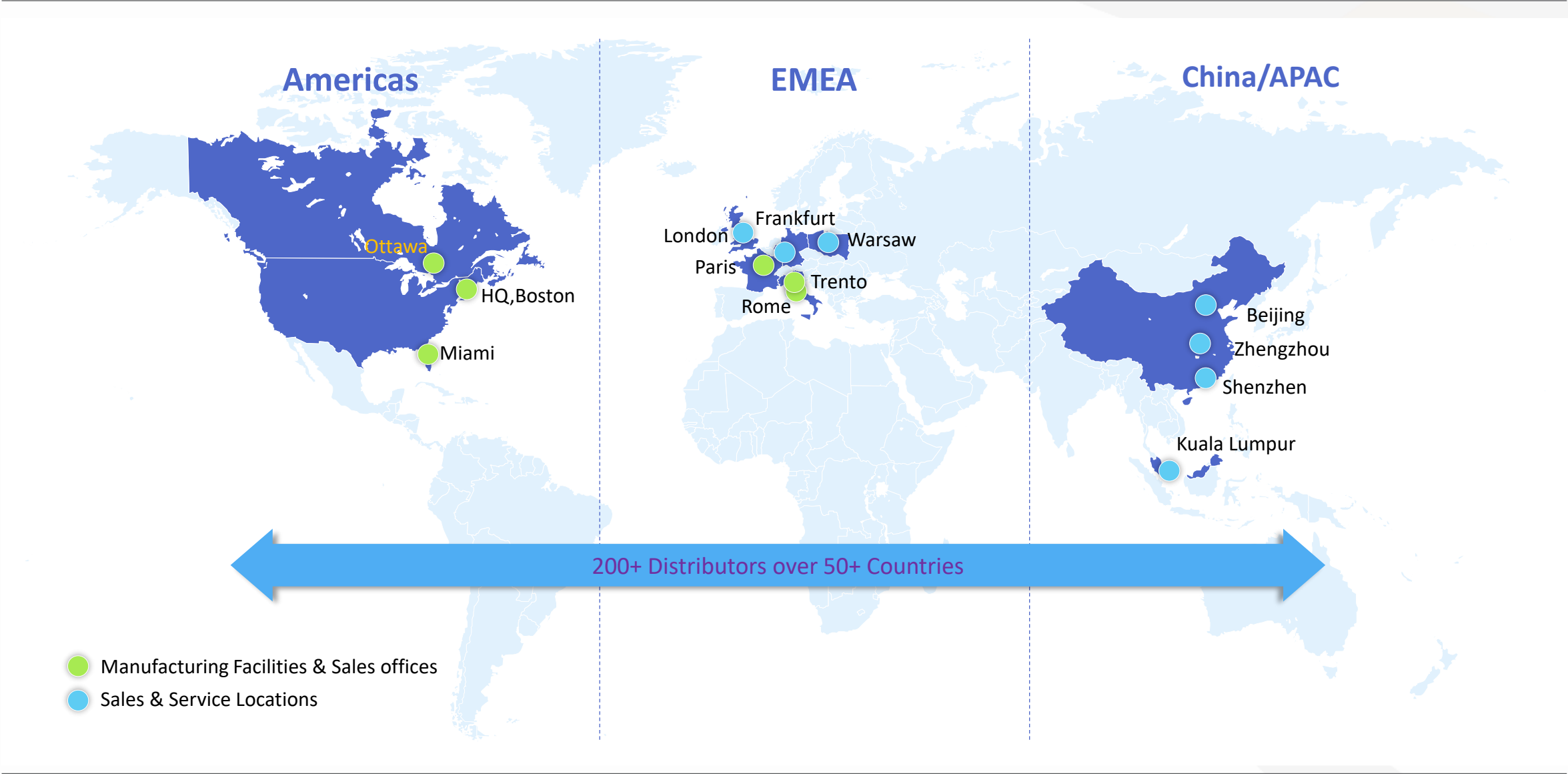# Broad Range of Products and Technologies

Functional & rheological analysis for grain, flour and dough

NIR & RF moisture and compositional analysis

Vision inspection for food production and process control

Wet chemistry analysis for agriculture, food, environmental and clinical applications
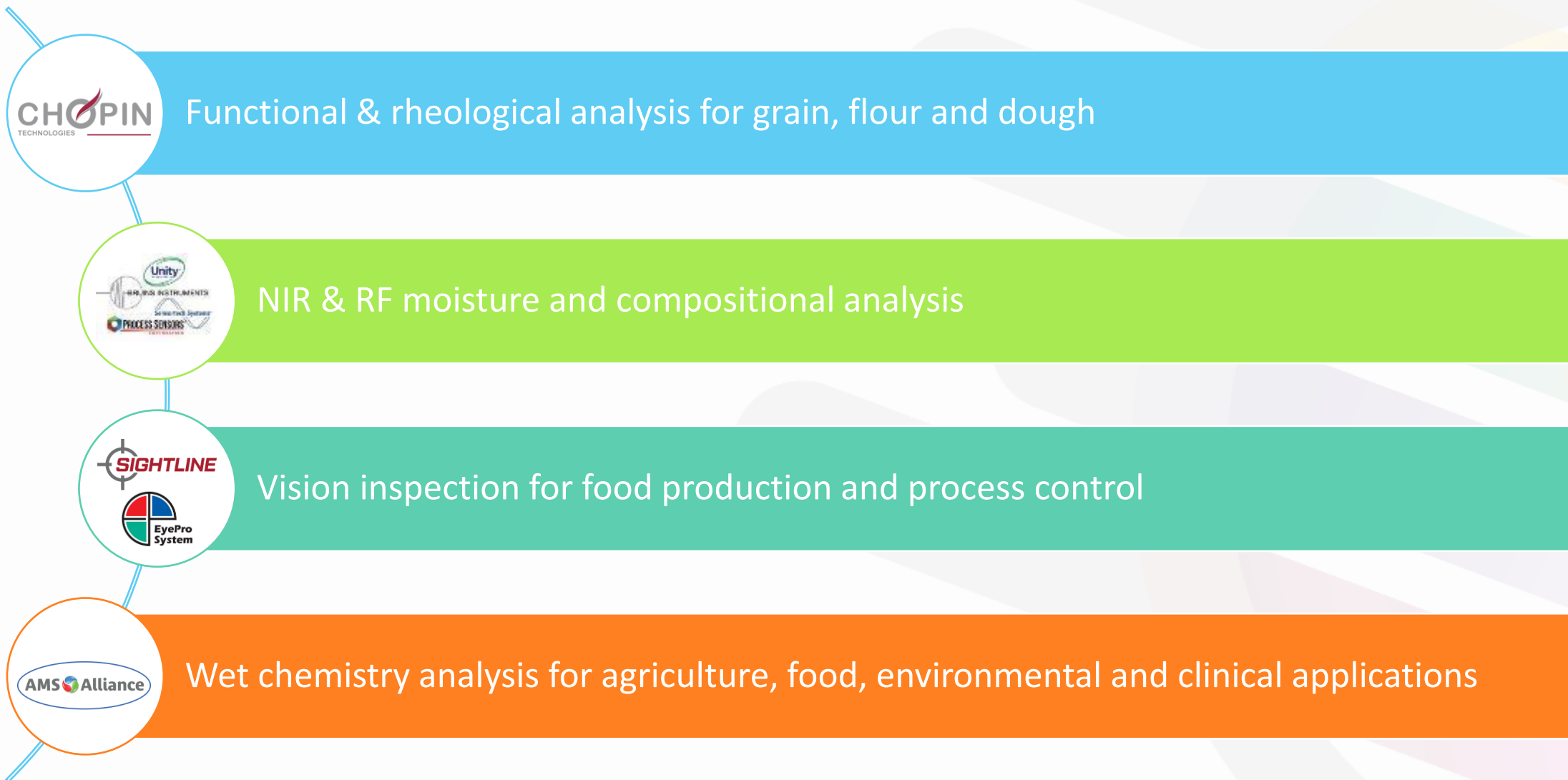
Extensive Global Sales and Service Network

Americas

- Ottawa
- HQ, Boston
- Miami

EMEA

- London
- Frankfurt
- Warsaw
- Paris
- Trento
- Rome

China/APAC

- Beijing
- Zhengzhou
- Shenzhen
- Kuala Lumpur

200+ Distributors over 50+ Countries

● Manufacturing Facilities & Sales offices
● Sales & Service Locations

KPM

Thank you!

hboyacioglu@kpmanalytics.com