Flour Milling Applications of the Alveograph

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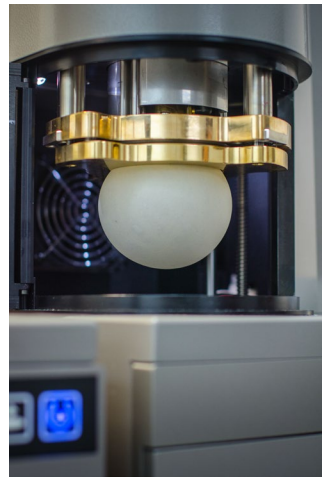
What is Alveograph?



Visco-elastic recorder!

Measures dough strength!

The Chopin Alveograph **assesses the ability of a dough** in which gluten is developed **to retain gas!**

The alveograph determines the gluten strength of a dough by measuring the force required to blow and break a bubble of dough.

Wheat, flour quality

- WHEAT KERNEL QUALITY
- MILLING and FLOUR QUALITY
- *PHYSICAL DOUGH (Rheological) PROPERTIES*
- BAKING QUALITY

Why do we measure rheology of flour, dough?

How to assess the quality of the flours?

- Physicochemical compositions!
- Rheological properties!
- Direct performance in the final product!

Why do we measure rheology of flour, dough?

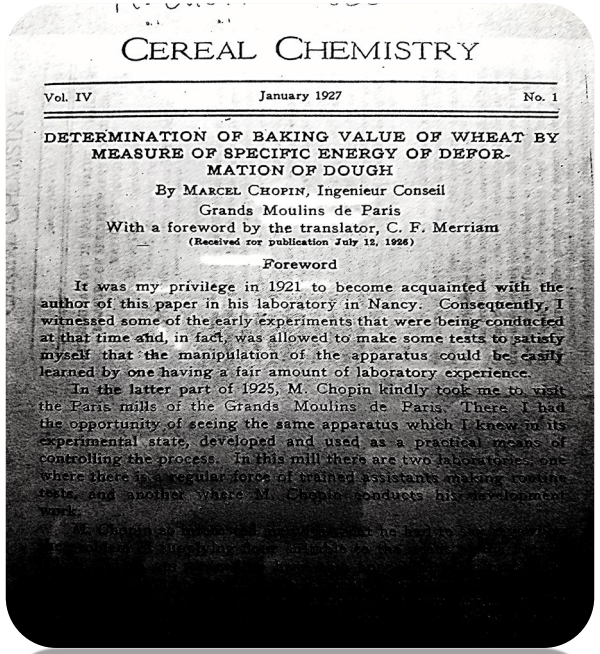
Rheological measurements on bread dough have long been used as a method to define its physical properties, the main aims of which are:

- ✓ To obtain a quantitative description of its mechanical properties,
- ✓ To characterize and predict its performance during processing and end-use,
- ✓ To obtain information related to its molecular structure and composition.

(Dobraszczyk, 2016; 2020)

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.



CEREAL CHEMISTRY

Vol. IV January 1927 No. 1

DETERMINATION OF BAKING VALUE OF WHEAT BY MEASURE OF SPECIFIC ENERGY OF DEFORMATION OF DOUGH

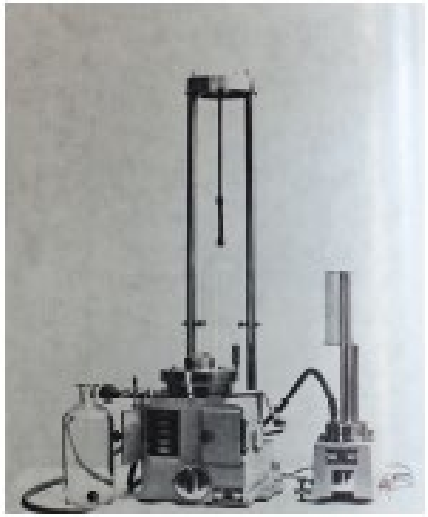
By MARCEL CHOPIN, Ingenieur Conseil
Grands Moulins de Paris
With a foreword by the translator, C. F. Merriam
(Received for publication July 12, 1926)

Foreword

It was my privilege in 1921 to become acquainted with the author of this paper in his laboratory in Nancy. Consequently, I witnessed some of the early experiments that were being conducted at that time and, in fact, was allowed to make some tests to satisfy myself that the manipulation of the apparatus could be easily learned by one having a fair amount of laboratory experience.

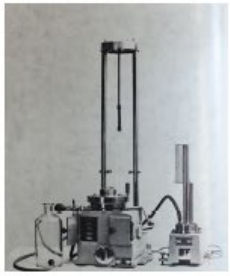
In the latter part of 1925, M. Chopin kindly took me to visit the Paris mills of the Grands Moulins de Paris. There I had the opportunity of seeing the same apparatus which I knew in its experimental state, developed and used as a practical means of controlling the process. In this mill there are two laboratories, one where there is a regular force of trained assistants making routine tests, and another where M. Chopin conducts his development work.

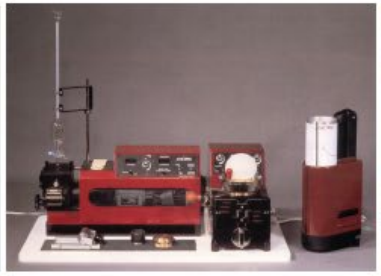
A constant evolution…

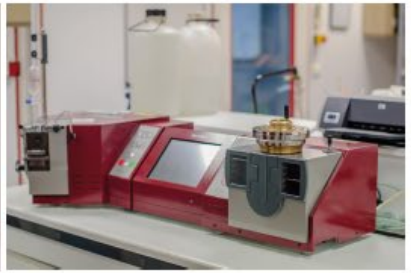


1920s

2014







1926 1er Alvéographe

1982 Alvéographe MA 82

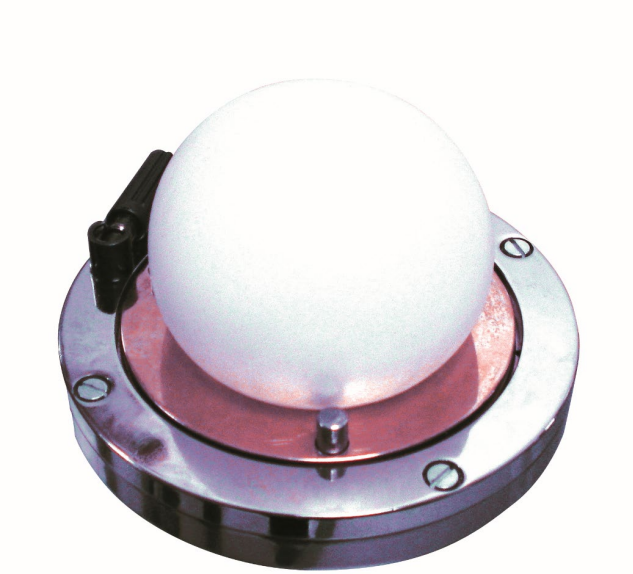
1987 Alvéographe MA 87

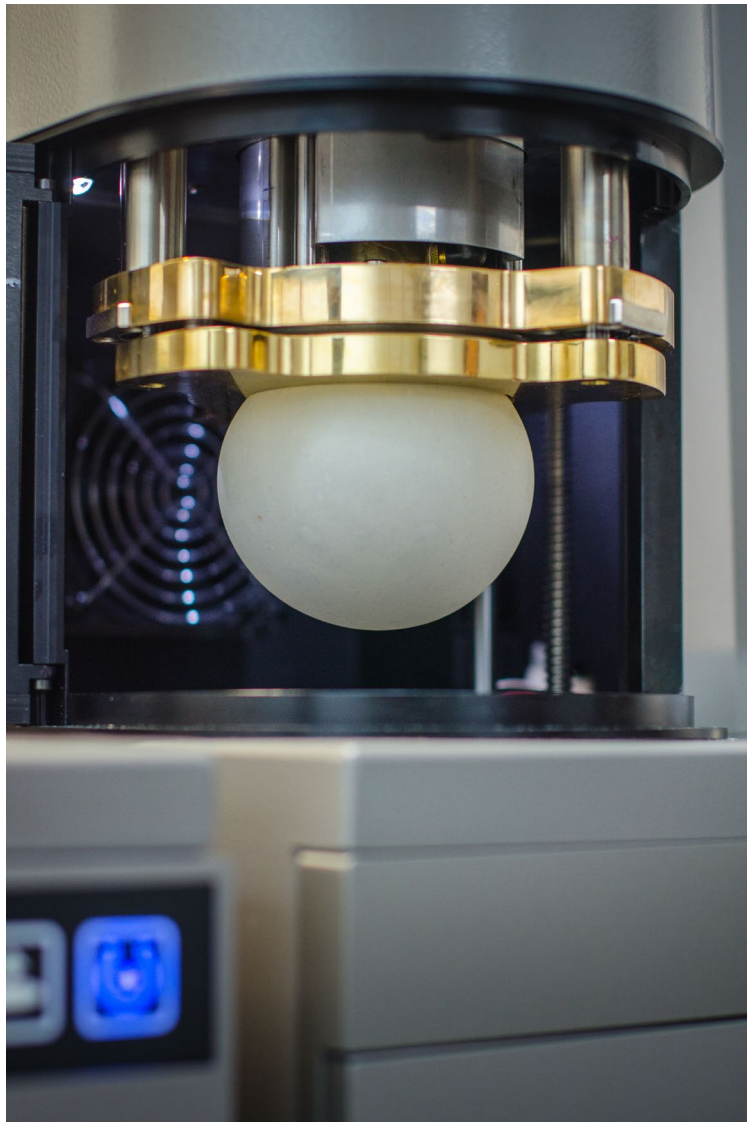
1998 Alvéographe NG

2014 AlveoLab

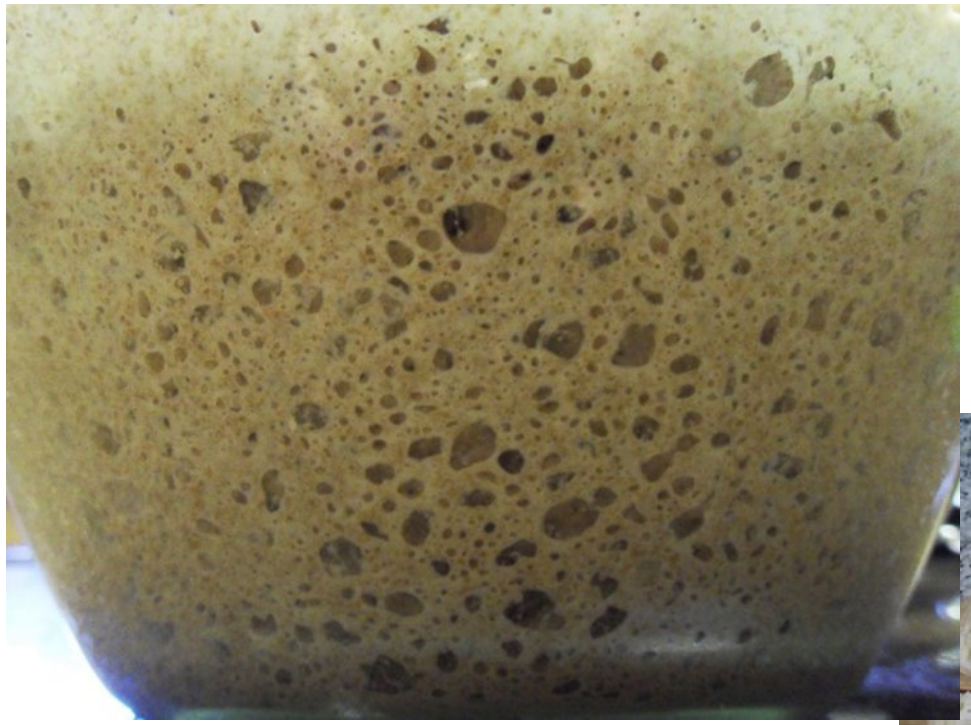
… but the same principle

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





Baking, a matter of bubbles!



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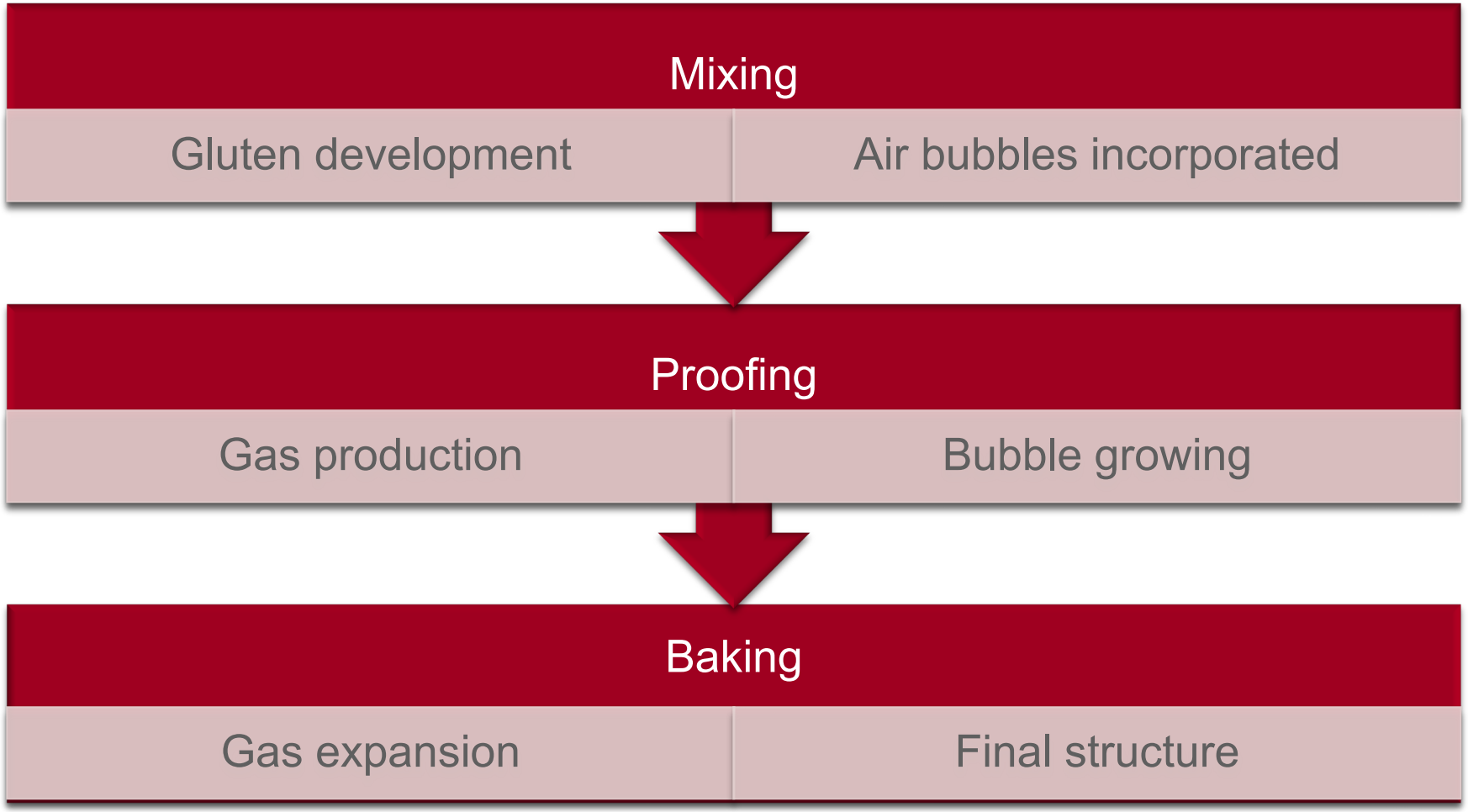


What is the objective of Alveograph?

➢ 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

The Alveograph standard test - How to Conduct a Test

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

Mixing
8min
24°C

Extrusion
+
shaping

Resting
20min
25°C

Blowing
20°C
65% RH

And more...

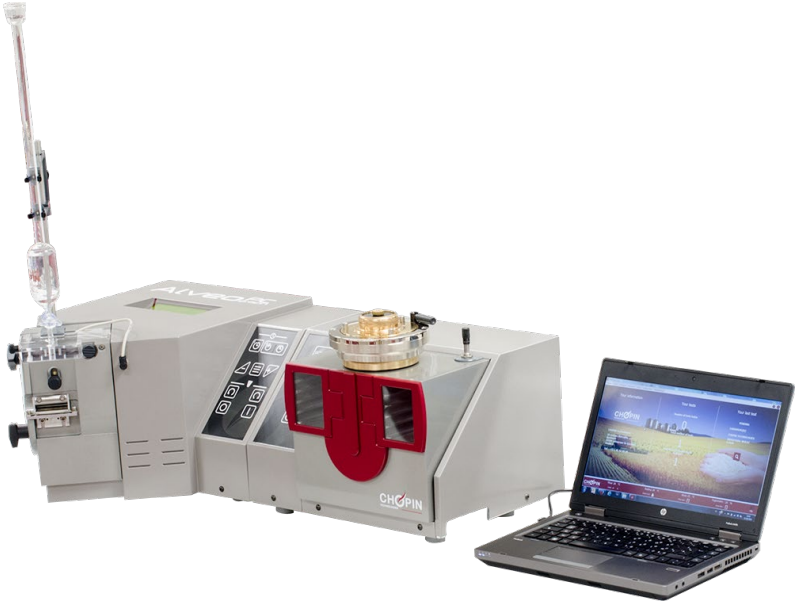
The test results!

How to read an Alveographic curve?

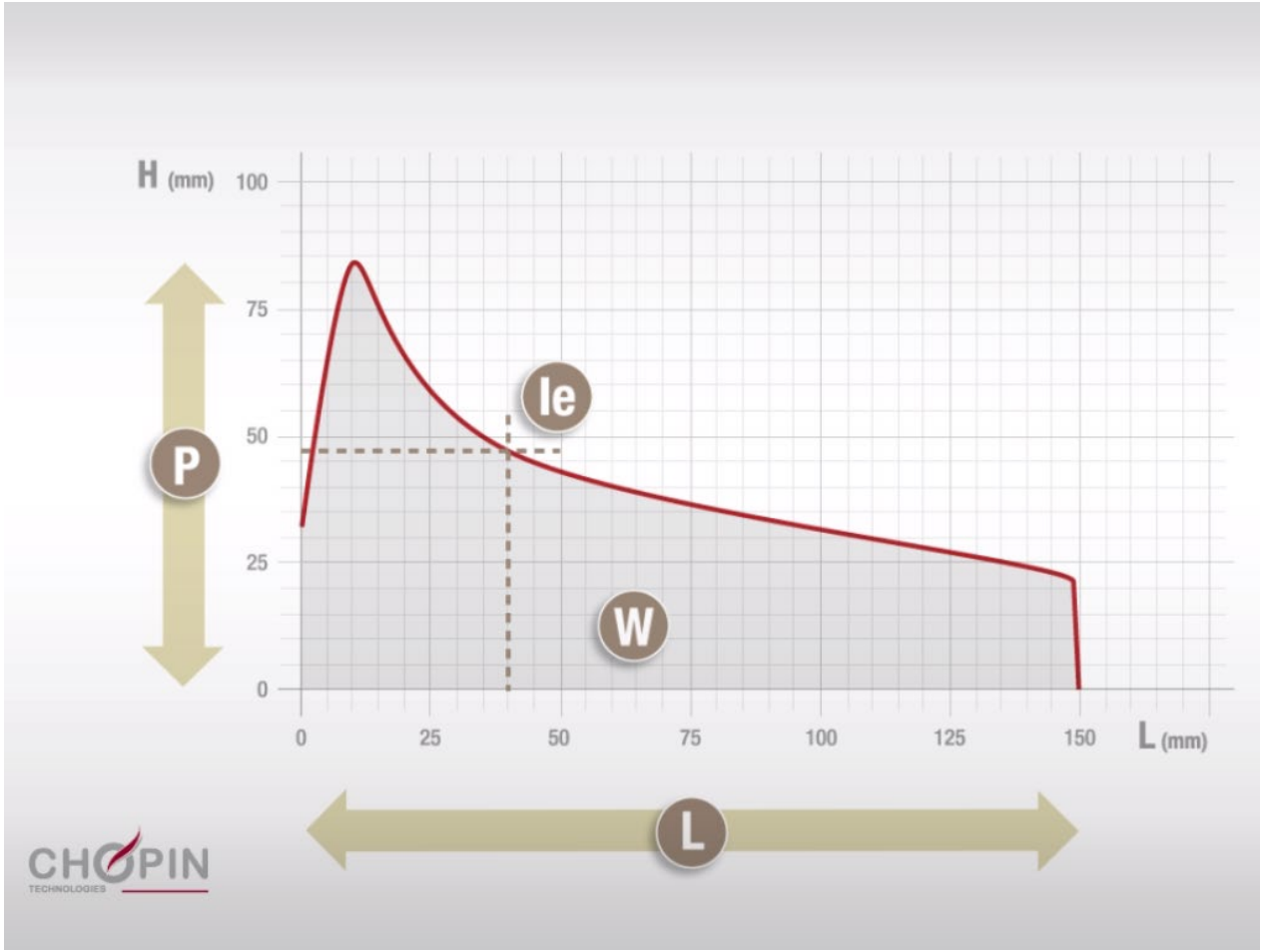
What do we measure?

- 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)

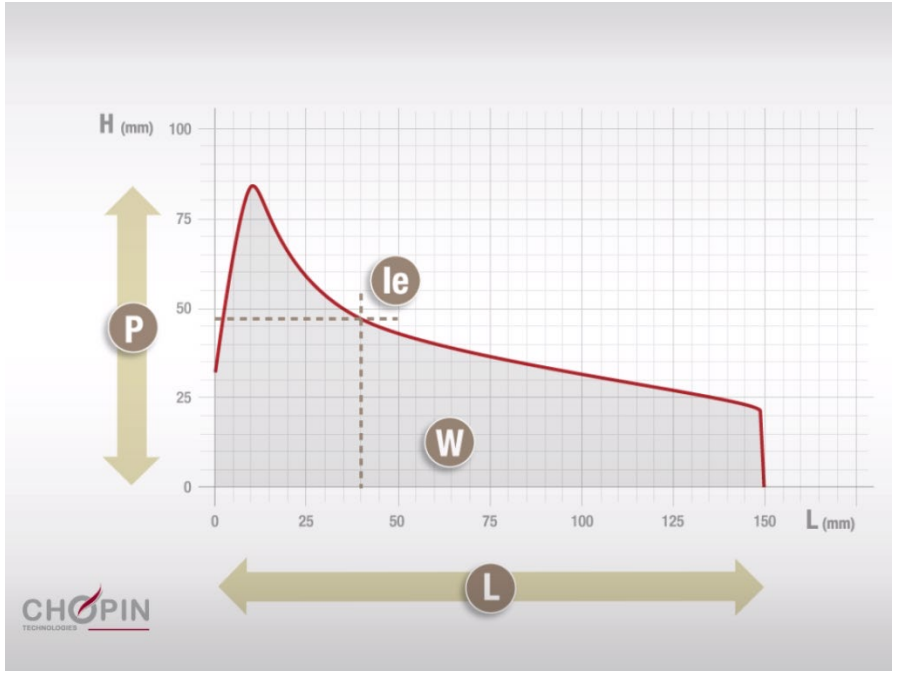
- **L: Extensibility** of the dough
(Maximum volume of air the bubble can contain)

- **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

Characteristic curve



Specifying flour based on Alveograph measurements :

- **P: Tenacity** of the dough

- A stronger dough requires more force to blow and break the bubble (higher P value).

- **L: Extensibility** of the dough

- A bigger bubble means the dough can stretch to a very thin membrane before breaking.
- A bigger bubble indicates the dough has higher extensibility; that is, its ability to stretch before breaking (L value).

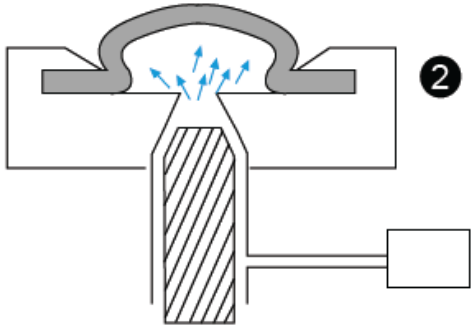
- **W: Dough baking strength**

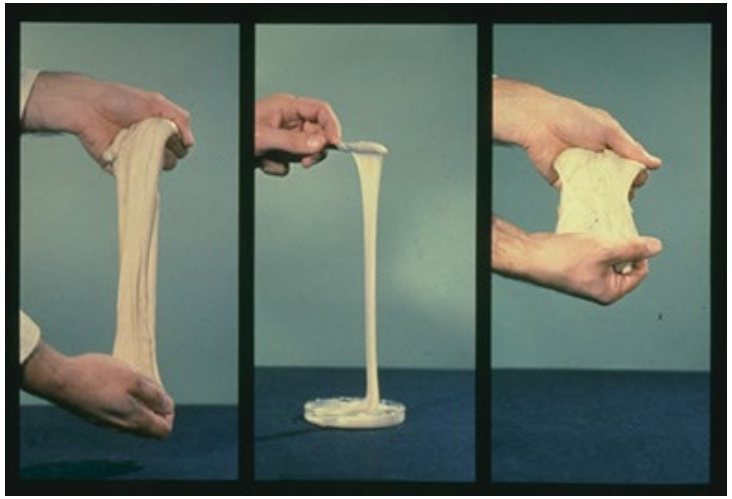
- A bigger bubble requires more force and will have a greater area under the curve (W value).

Tenacity, P

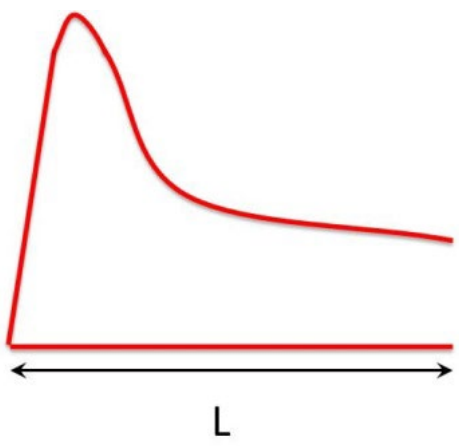
- The parameter P is the maximum overpressure needed to inflate the dough bubble. The parameter is also called the dough tenacity.
- P is one of the most used alveograph parameters.

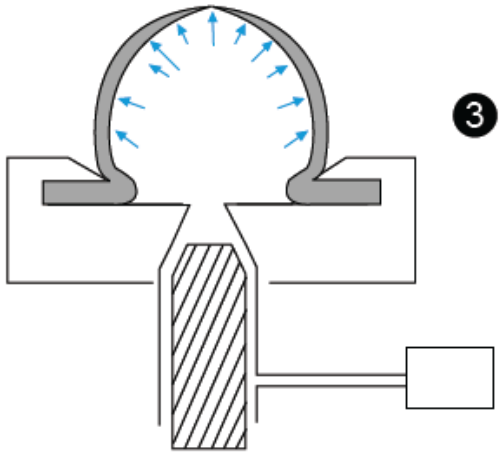
- It is the indicator of dough resistance to deformation, but it has also been claimed that it is an indicator of dough tensile strength in the initial stage of deformation, related to the stiffness, shortness and tightness of the dough, an indicator of dough stability.





Extensibility, L or G



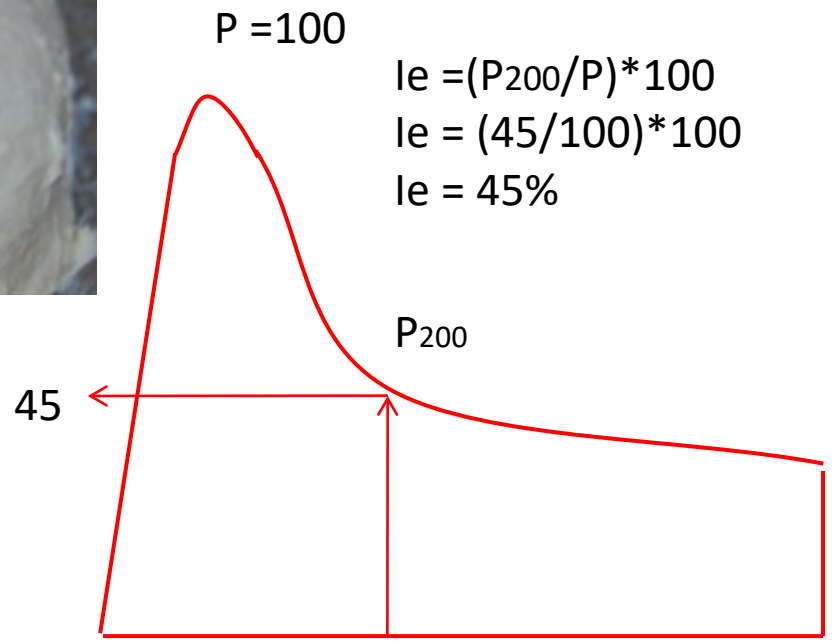


- L (average abscissa to rupture), it is a measure of how much the dough can be extended before it breaks.
- L has strong, positive correlations with several bread properties, including bread volume!

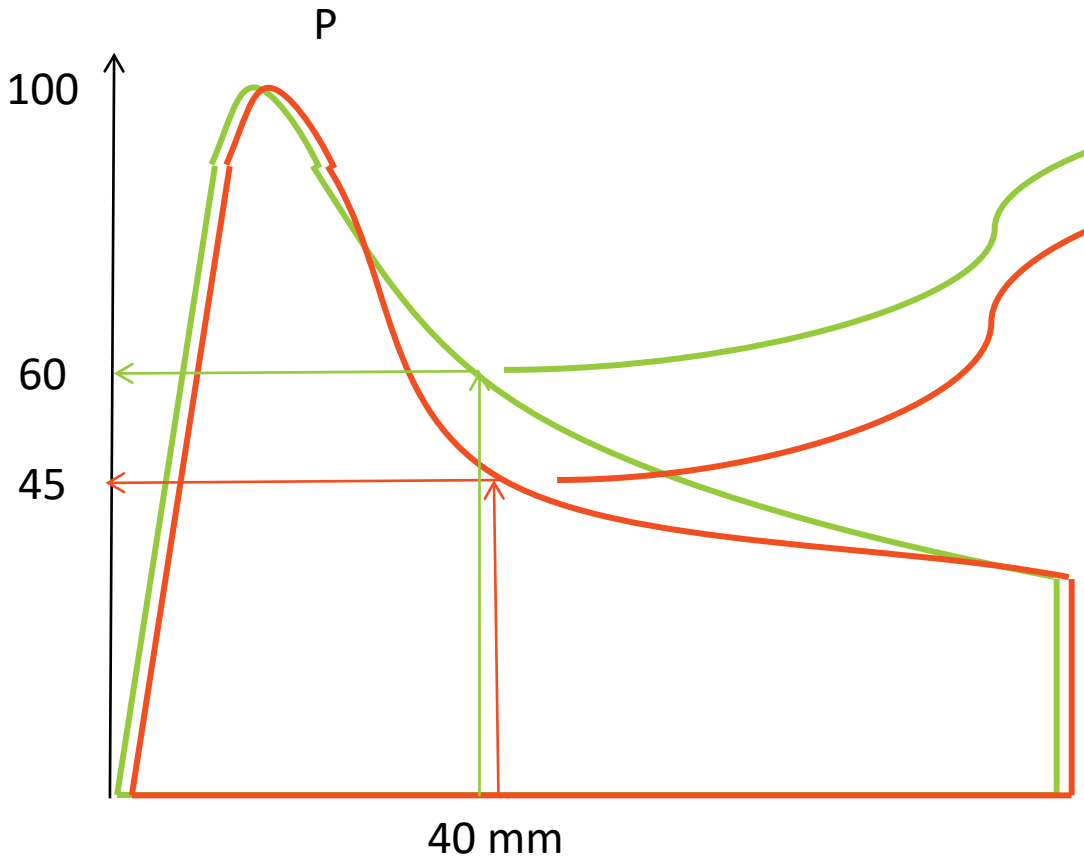
- G (swelling index) is related to the spring and the shortness of the dough!

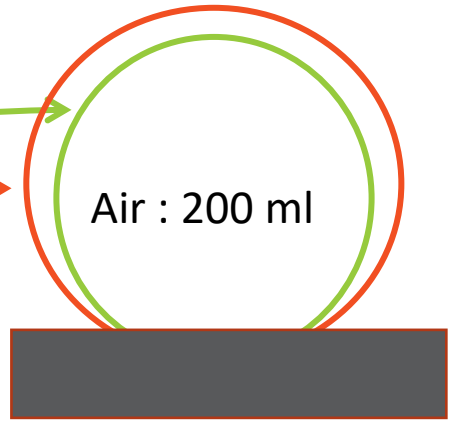
Elasticity, I.e.

- **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.**



Focus on elasticity measurement





Ie = 45/100 = 45%

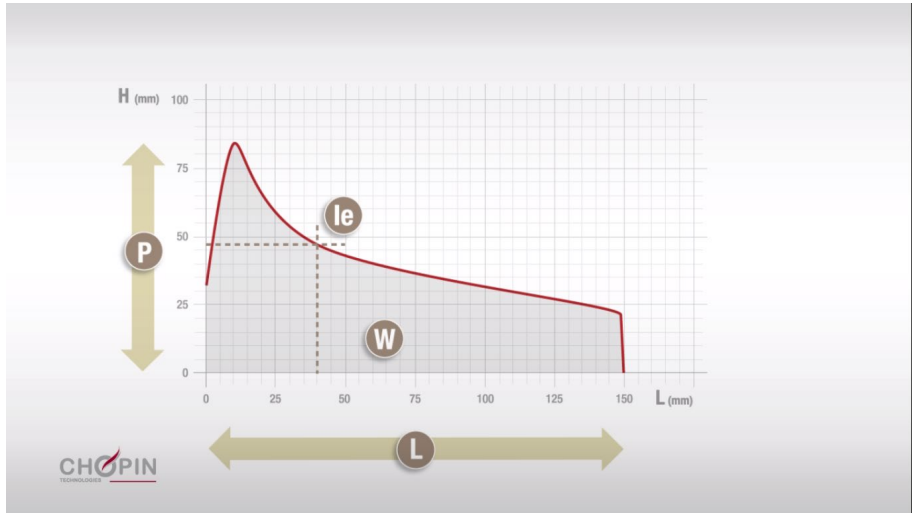
Ie = 60/100 = 60%

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!



Chopin Alveograph

Main Applications

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

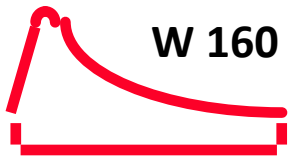
Benefits of the Alveograph for Millers

MILLERS

- ✓ Monitor incoming wheat or flour to ensure you are starting with high-quality ingredients,
- ✓ Improve efficiency by conducting multiple tests throughout the day,
- ✓ Understand dough behavior for testing new recipes and controlling additives,
- ✓ Measure and adapt flour according to specifications,
- ✓ Understand dough behavior to provide consistent products for your brand,
- ✓ Use proven, industry-standard analysis for your testing procedures!

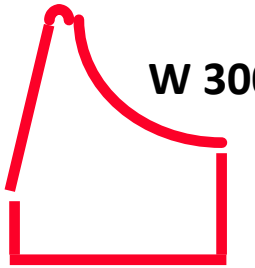
Classify wheats with the Alveograph

M. HUNTSMAN

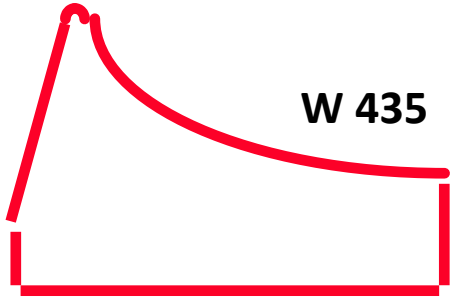


FRENCH WHEAT

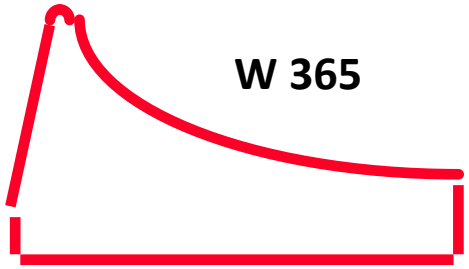
CLEMENT



BAHIA



CWRS

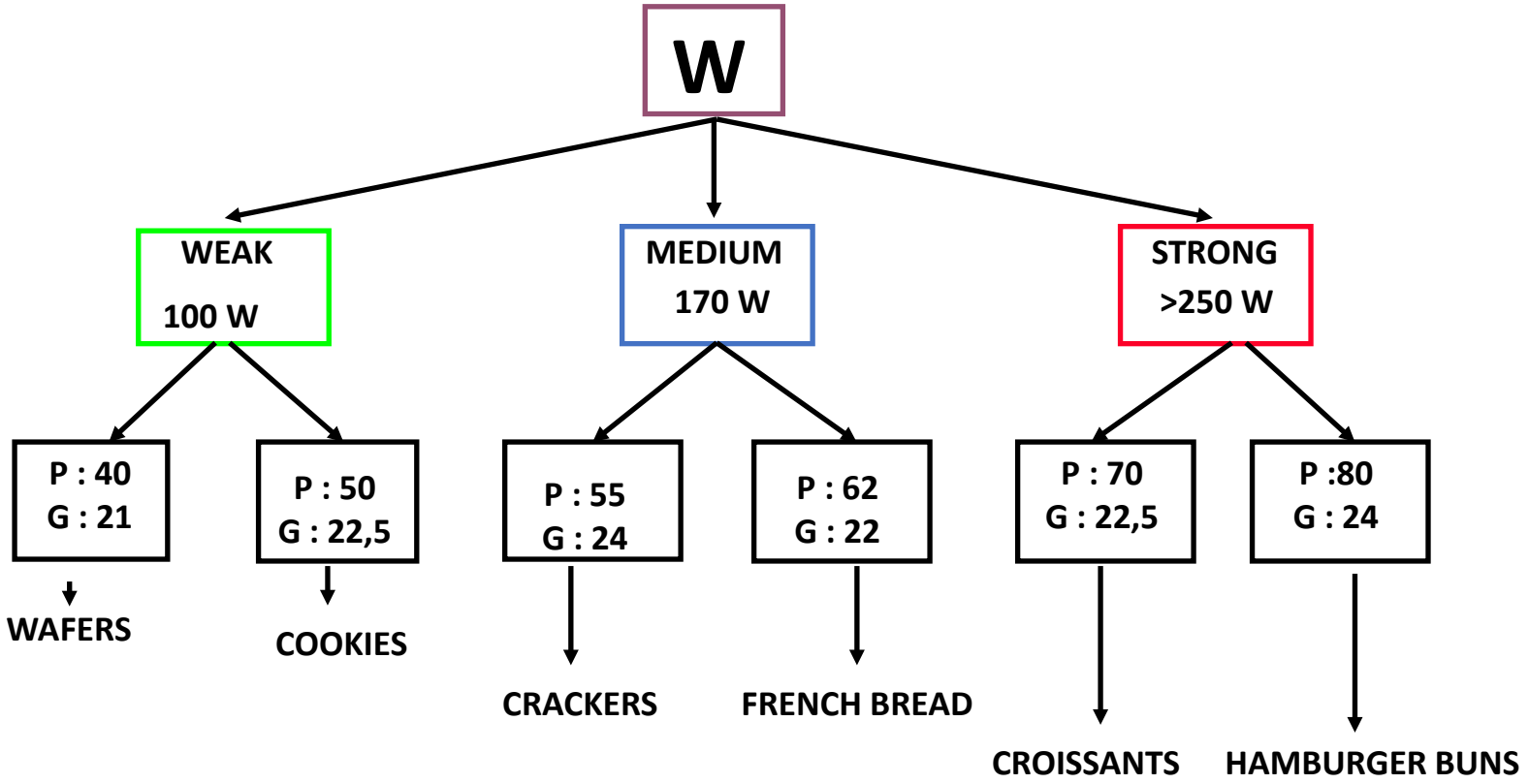


DNS

US SOFT WHEAT

Classify/Evaluate flours with the Alveograph

Michel Dubois, 1988



Blend wheats or flours

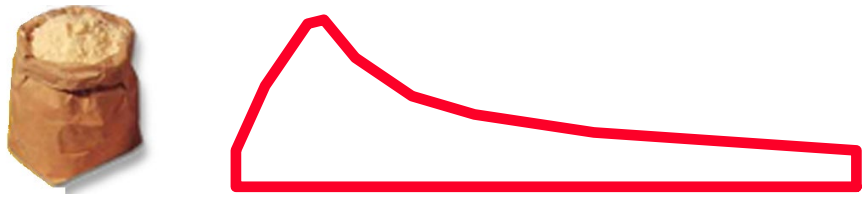
Wheat or flour blending is an essential milling operation.

The Alveograph data W, P, L, P/L are well defined physical values. They follow the mathematical rule for blends, and allow the user to:

- Either foresee the future characteristics of two or more flours which will be mixed in predetermined proportions.

- Or research on the blend's percentages from 2 or more silo cells of different qualities in order to obtain flours with given characteristics.

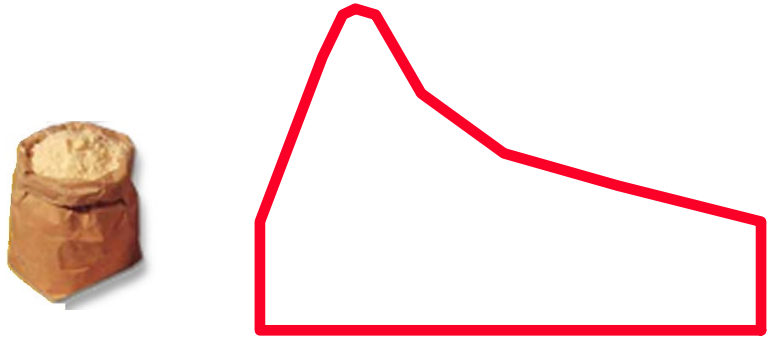
Blend wheats or flours



50 %

W = 96
G = 19.4 P = 46

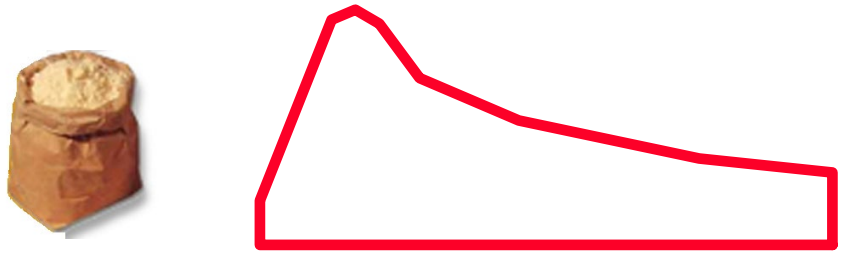
+



50 %

W = 224
G = 17.5 P = 103

=



100 %

W = 160
G = 18.5 P = 74

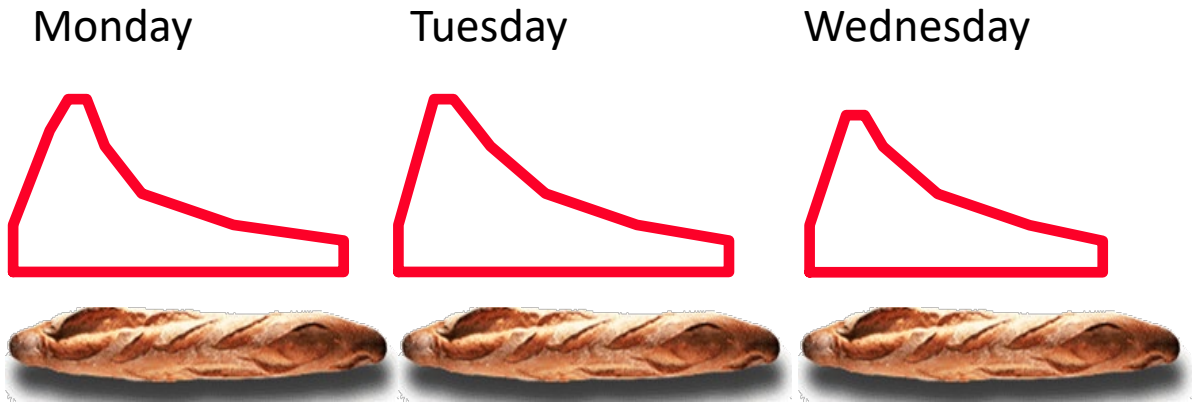
W = 96 x 0.5 + 224 x 0.5 = 160

Protein quantity is not protein quality!

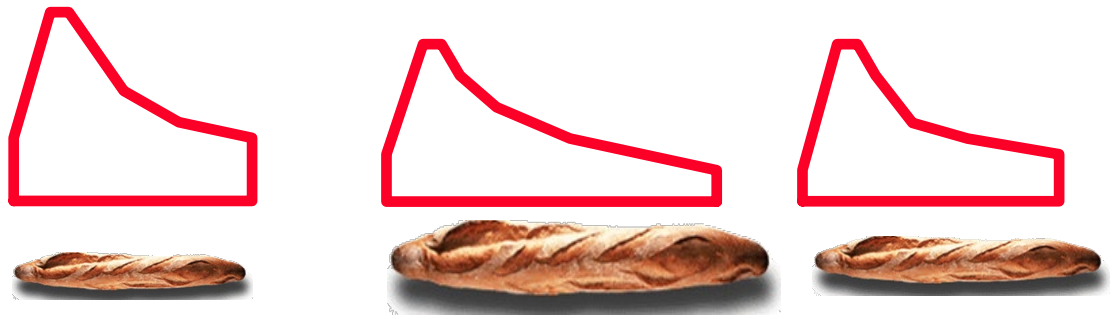
Hard White	Pacific Northwest		California	Southern Plains			Northern Plains	
	Low	Very High	High	Low	Medium	High	High	Very High
Wheat Grade Data:								
Test Weight (lb/bu)	61.4	60.9	63.8	61.6	62.6	62.5	62.3	62.3
(kg/hl)	80.7	80.1	83.8	81.0	82.3	82.2	81.9	81.9
Damaged Kernels (%)	0.0	0.0	0.0	0.0	0.0	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

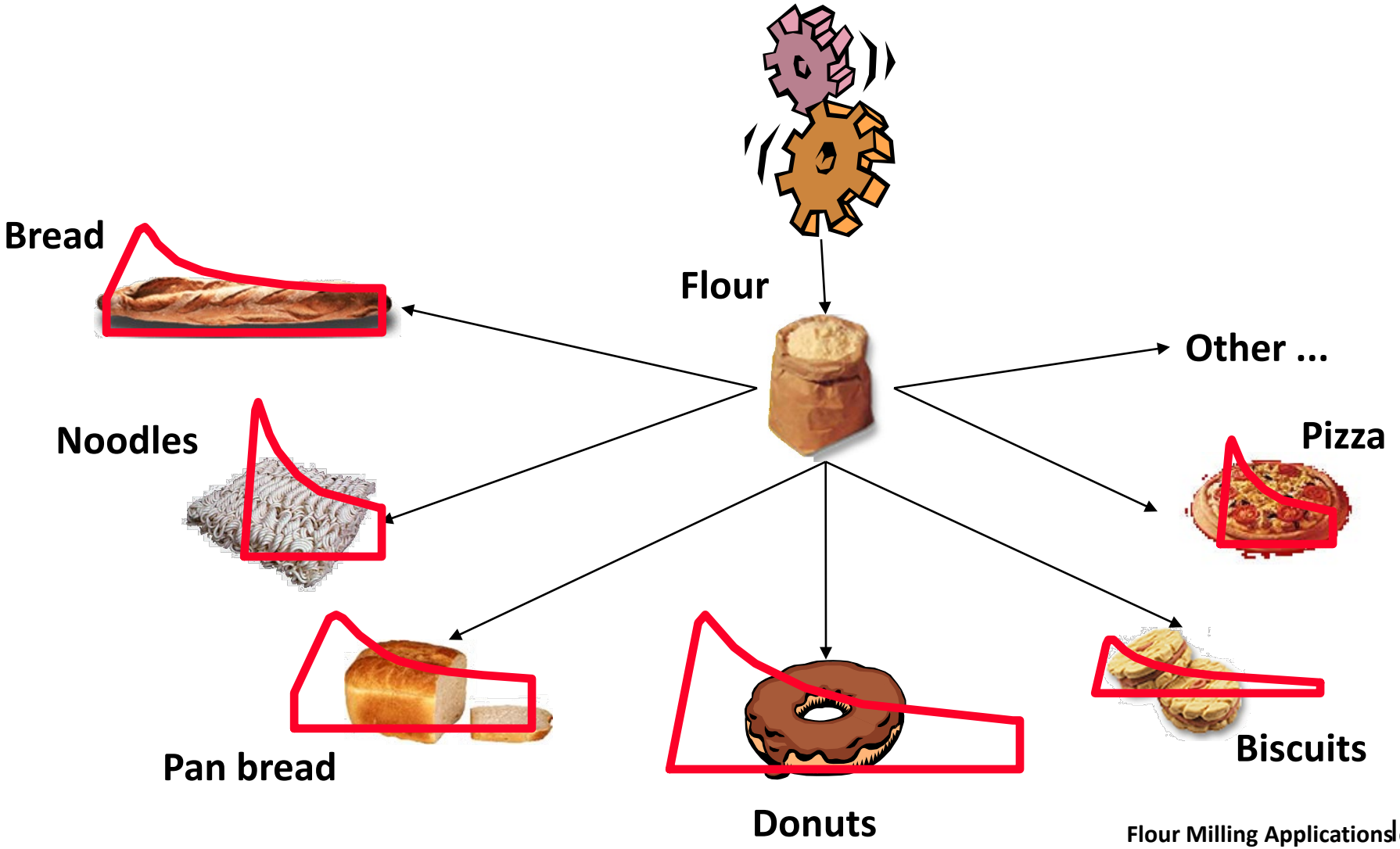
Constant



Not constant



Make flours adapted to their application

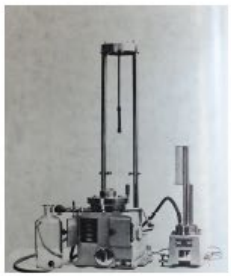


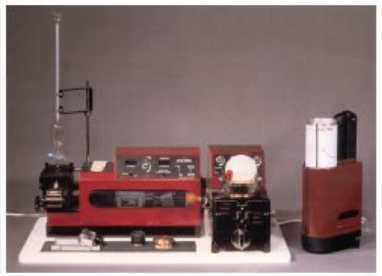
A constant evolution…

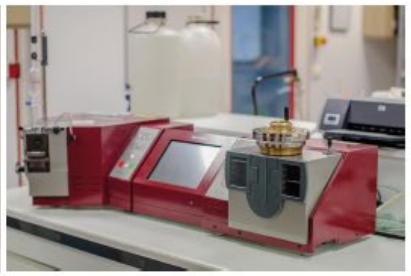
1920s — 1st Alveograph

2014 — 1st Alveolab

2022 — Whole Wheat Flour test







1926 1er Alvéographe

1982 Alvéographe MA 82

1987 Alvéographe MA 87

1998 Alvéographe NG

2014 AlveoLab

Whole wheat flour testing by Alveograph

- **Whole wheat flours can be very different from one another…**
  … but have common characteristics:
  - Strong water absorption capacity,
  - Long development time of the dough,
  - Increased fragility of the gluten network due to the presence of bran particles,

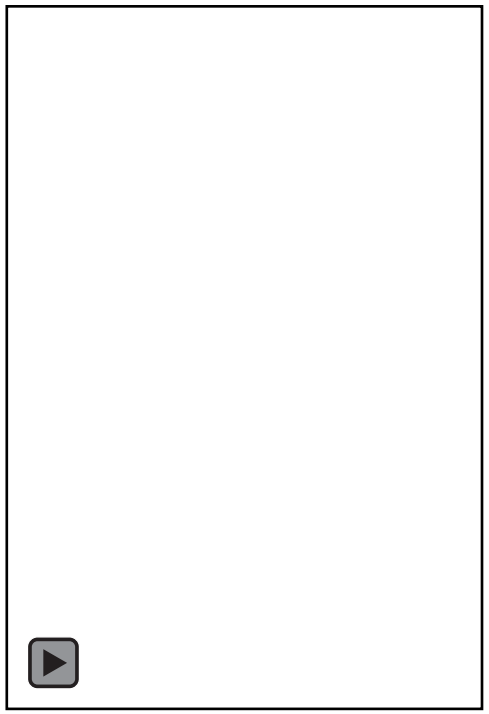
Standard protocol
(NF EN ISO 27971)
not adapted

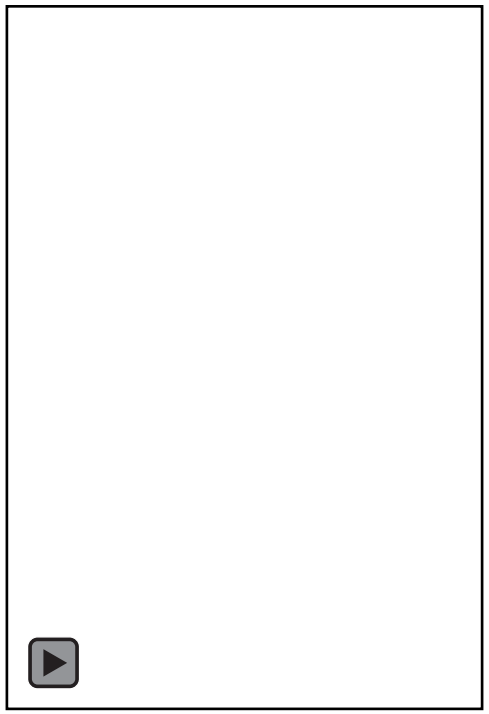
- **Thanks to the numerous Alveolab adjustment possibilities …**
  … creation of adapted protocol :
  - higher hydration,
  - and a higher kneading speed to ensure optimum development of the gluten network,
  - a lower swelling rate to ensure a smooth deformation of the dough,

Whole Wheat Flour protocol
=
OK

Whole wheat flour – Standard vs Whole wheat flour protocol by Alveograph

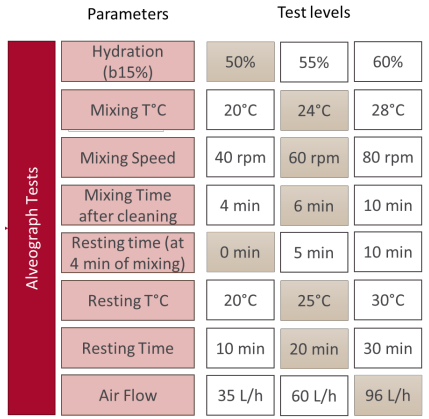
Protocol	NF EN ISO 27971	Whole Wheat Flour
Hydration	50 % b15	60 % b15
Mixing rotation speed	60 rpm	80 rpm
Blowing bubble air flow	96 l/h	40 l/h





This *Whole Wheat Flour protocol* is the result of a long development work:

- Testing many different protocols to find the best combination
- Validation of this protocol on :
  - a wide variety of flours,
  - by different operators
  - and on different instruments
- Development of a specific algorithm and software to meet the technical challenges posed by complete flours (L detection)
- Extensive validation tests of this new software



Alveolab Test matrix:
Example of the combinations tested to develop the Whole Wheat Flour protocol

Whole wheat flour protocol by Alveograph: How to conduct a test

- No change for the operator (compared to NF EN ISO 27971)
- Protocol differences (hydration level, kneading speed, air flow) are automatically managed by the Alveolab
- The duration of a test is identical

Mixing
8min / 24°C

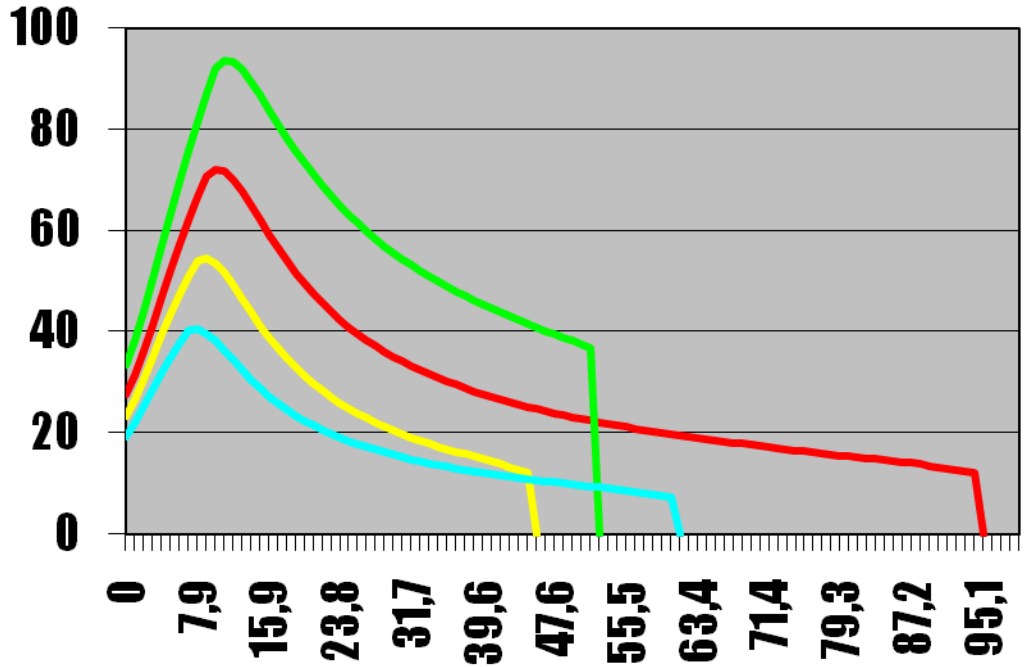
Extrusion + shaping

Resting
20min / 25°C

Blowing
20°C / 65% RH

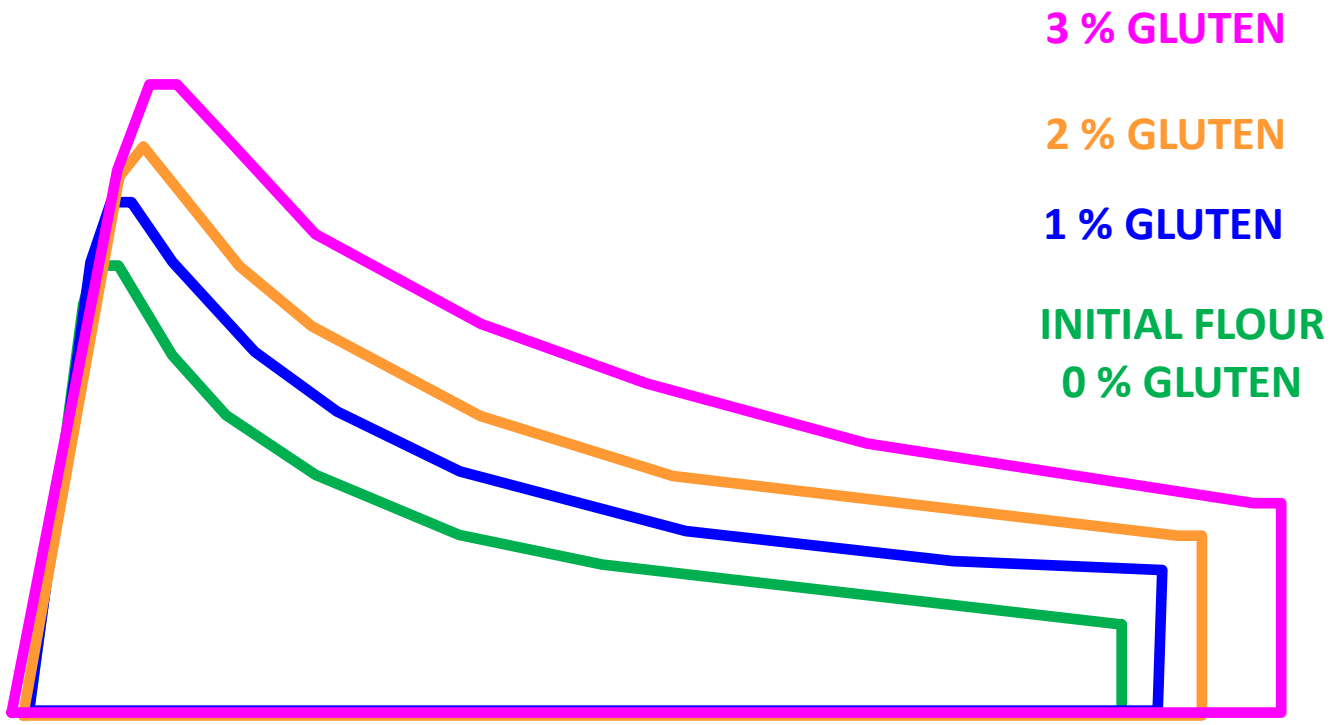
NB: As with white flours, the behavior of the doughs (water absorption speed, extrusion speed, stickiness ...) vary greatly from one flour to another

Durum wheat protocol *(Triticum Durum)*

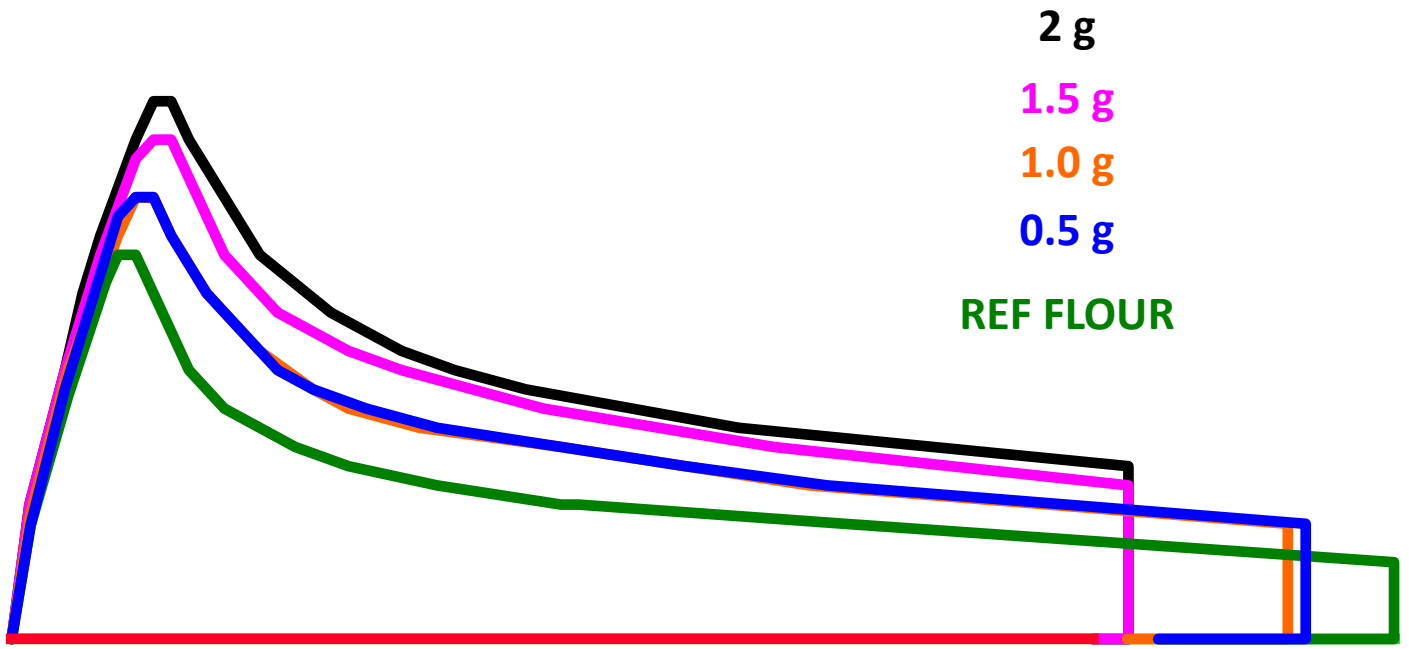


Semolina type	Particle size
Fine	+/- 200 µm
Medium	+/- 300 µm
Coarse	+/- 400 µm
Twin Peak	250-350 µm

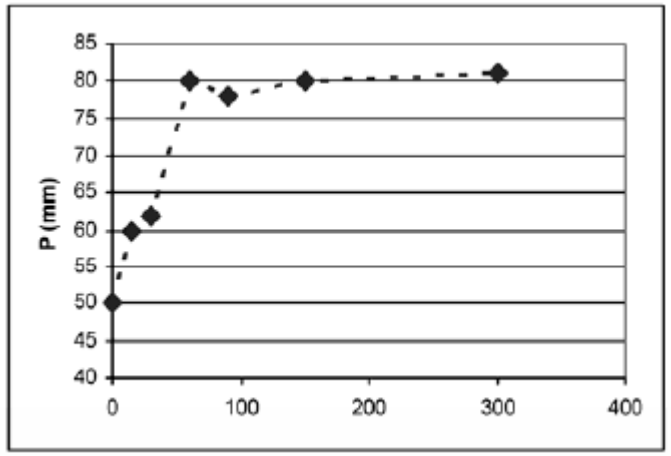
Effects of Additives: Vital Wheat Gluten

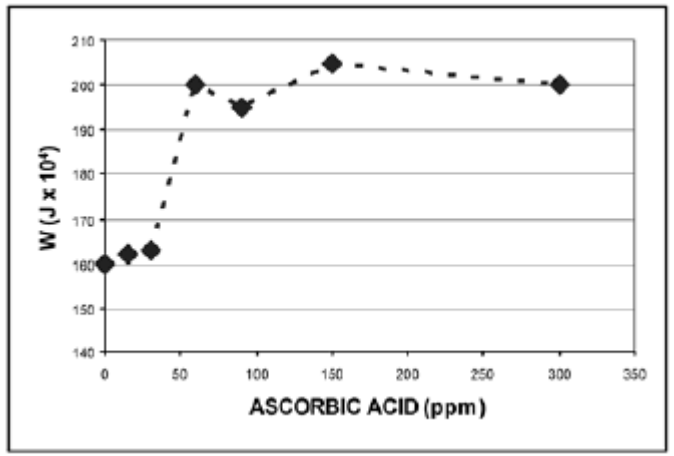


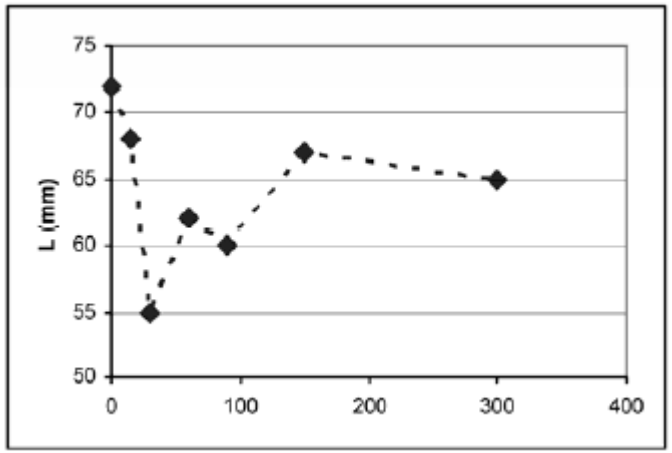
Effects of Additives: Ascorbic acid



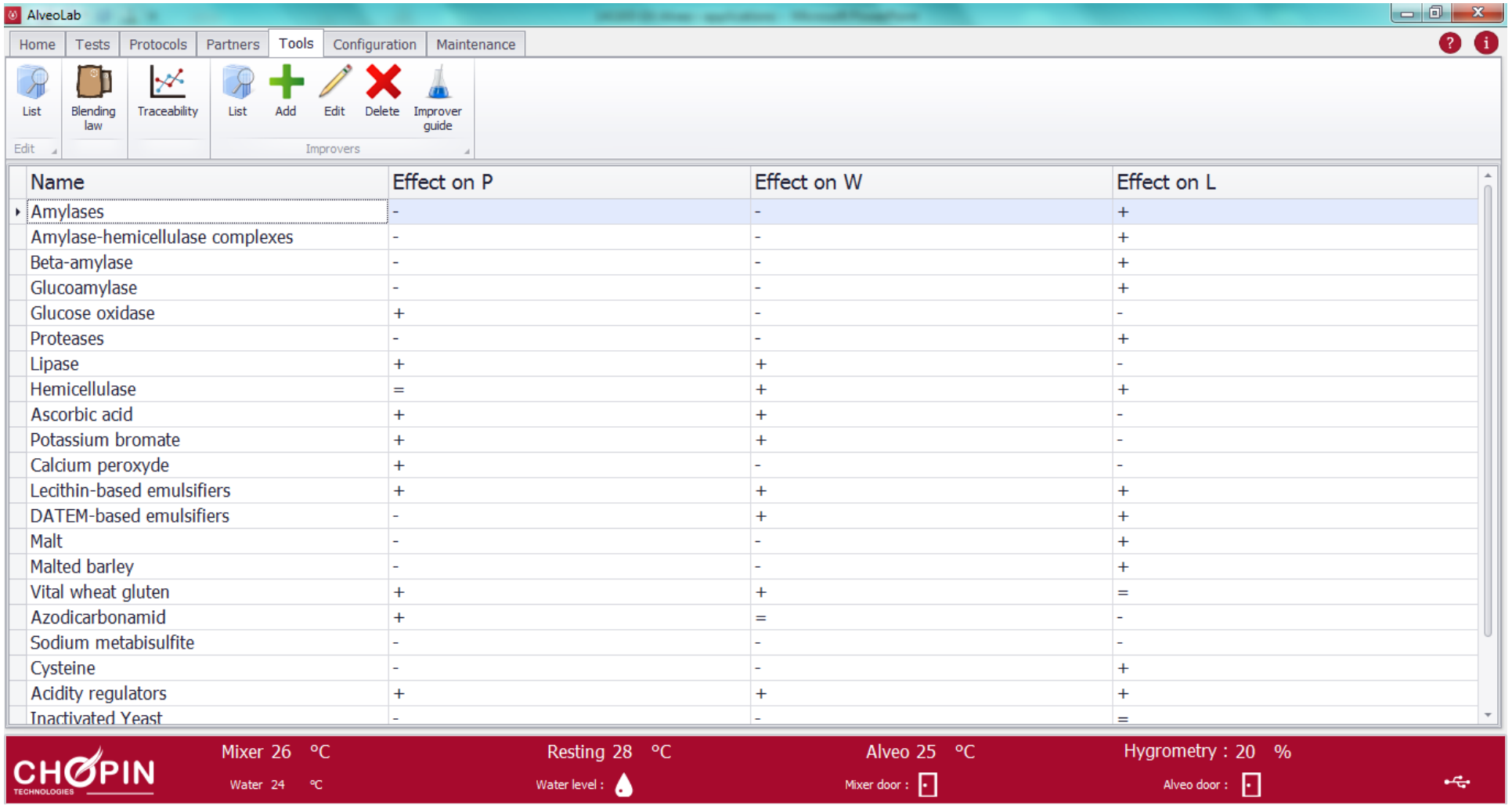
Effects of Additives: Ascorbic acid







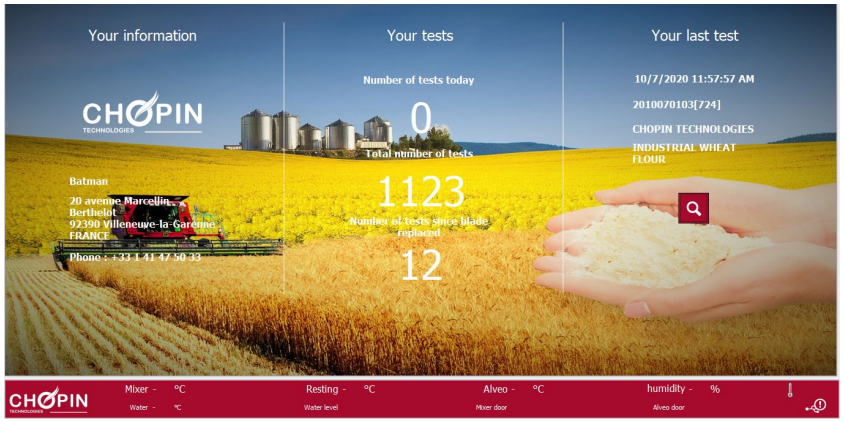
Effects of some additives on the Alveograph curve



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	-	-	=

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:

TEMPERATURES 

SPEEDS 

TIMES 

SAMPLES 

HYGROMETRY 

AIR FLOW 

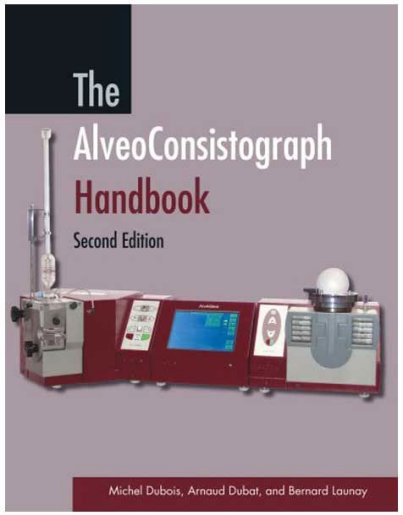
Parameter	Minimum	CHOPIN standard	Maximum
Water temperature	15°C	**20°C**	22°C
Mixer temperature	18°C	**24°C**	35°C
Mixing speed	30 rpm	**60rpm**	100 rpm
Mixing time before cleaning	0.5 min	**1 min**	3 min
Cleaning time	0 min	**1 min**	3 min
Mixing time after cleaning	0 min	**6 min**	60 min
Resting time during mixing	0 min	**0 min**	60 min
Mixing time after resting	0 min	**0 min**	60 min
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
Alveo analysis chamber relative humidity	30%	**65%**	90%
Air flow	40 L/h	**96 L/h**	110 L/h
Air insufflation Time	4 s or 4 ml	**-**	50 s or 33000 ml
Acquisition time	30 s	**-**	3600 s

KPM

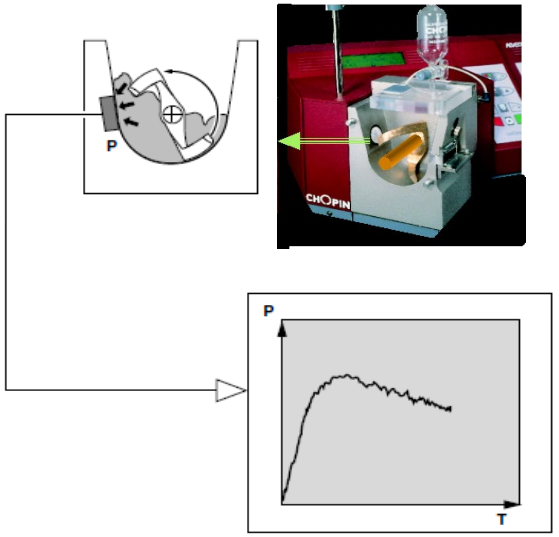
Focus on Alveograph test at adapted hydration

The Alveograph is perfectly suited for strong hard wheats!

Adapted hydration protocol Available since 1998



- Hydration determined thanks to the **Consistograph**
- Test is about 5 minutes
- Obtained results are indicated with an "HA" index



Now Standardized !
ICC 188

CONCLUSION

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.

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

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

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.

KPM Analytics Introduction

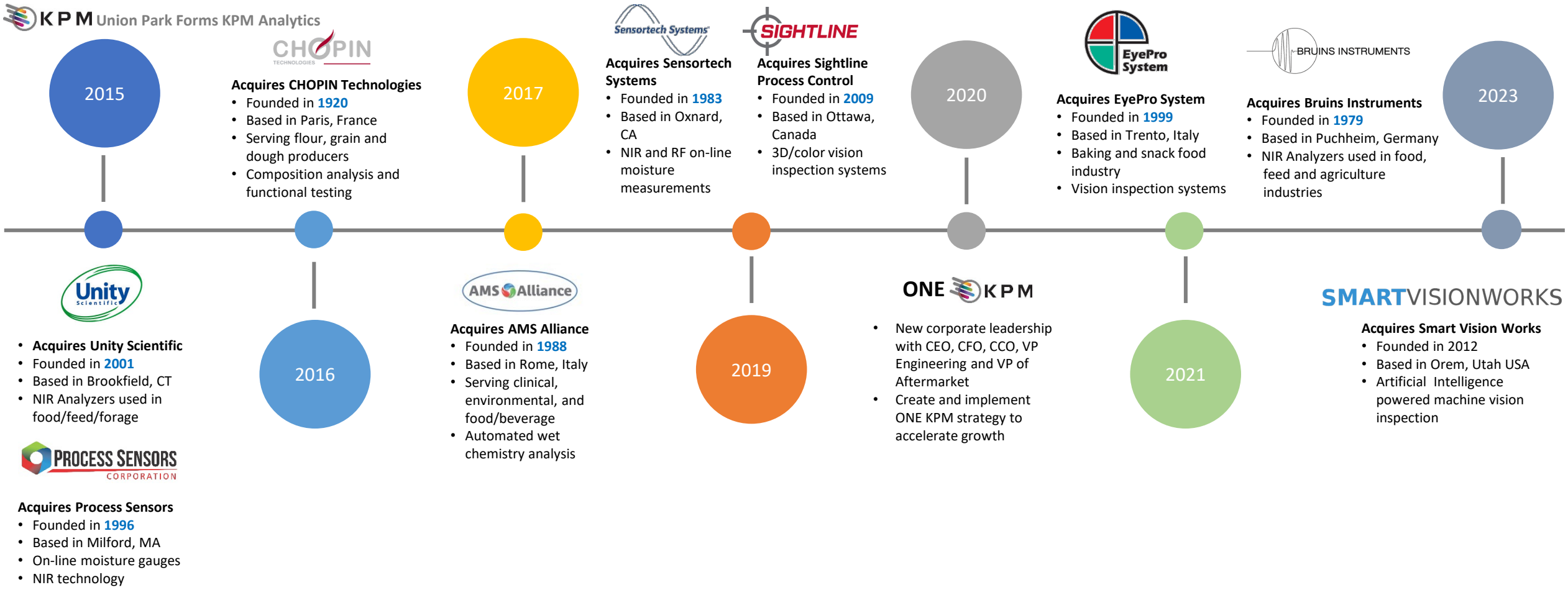
Our Mission

We craft assurance.

For our partners. For their customers.

Timeline and Progression of KPM Analytics

KPM Analytics brands have long and successful histories servicing customers worldwide



Industries We Serve

KPM's main focus is serving food producers, helping them ensure quality and protect their brand.

KPM is leading the industry for quality solutions at all stages of production.

Food Production Agriculture Feed & Forage Environmental Industrial

Our product lines are also widely used in agriculture and feed and forage to measure critical quality parameters.

Environmental, chemistry and industrial industries benefit from our accurate lab and sensing technologies.

A Global Team

KPM customers are supported by our global sales, service and authorized distribution network.

9
9 product brands based in 5 countries and growing.

200 +
Over 200 distributors worldwide.

15,000 +
Over 15,000 installations around the world.

U.S.A. (Boston)
+1 (774) 462-6700

Canada (Ottawa)
+1 (800) 768-6821

U.K. (London)
+44 1536 408066

France (Paris)
+33 01 41 47 71 38

Poland (Warsaw)
+48 22 6739526

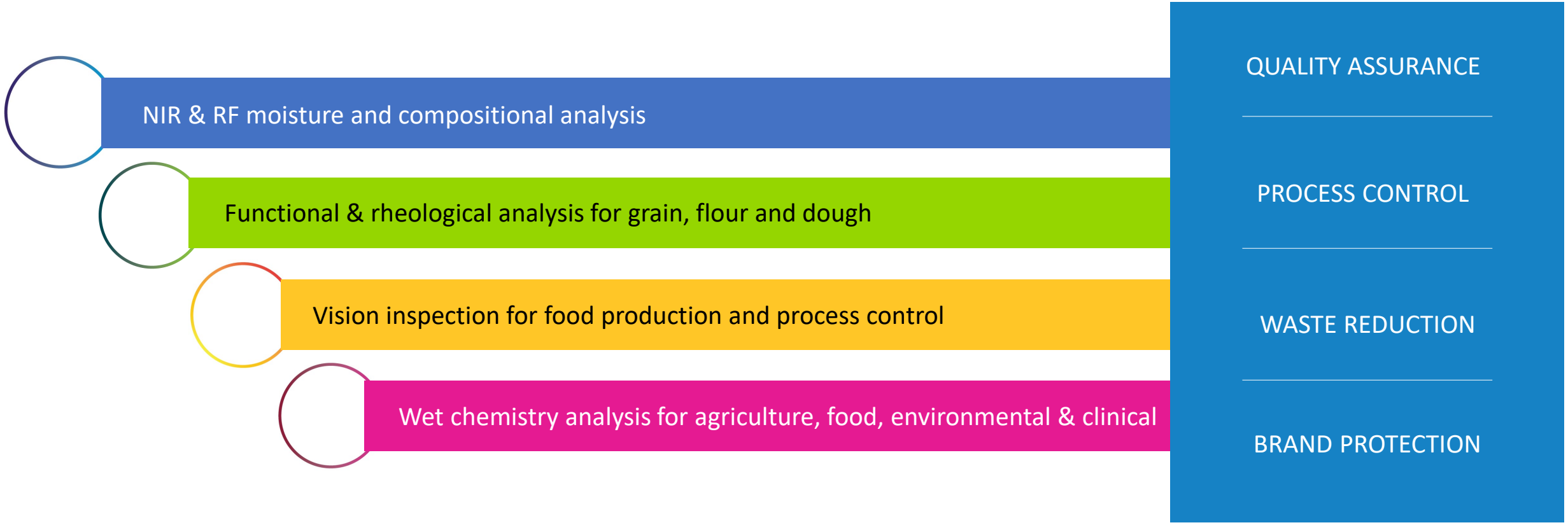
Germany (Frankfurt)
+49 (6721) 988 6720

Italy (Rome)
+39 0774 354441

China (Beijing)
+86 (10) 63345789

Malaysia (Kuala Lumpur)
+86 (10) 6334 5780

Solutions for Every Stage of Production



Thank you!

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