Evaluating Wheat and Corn Flours for Tortilla Production

Dr. M. Hikmet Boyacioglu
Cereal Scientist
Applications Development Specialist
KPM Analytics
hboyacioglu@kpmanalytics.com

TIA Tech Conference
October 13-14, 2021
Long Beach, CA, USA

Introduction

TORTILLA UPDATE

Value, flexibility, and health and wellness innovation spur category growth!

The value and flexibility of tortillas have proved to be a winning formula for the grain-based foods category during the past year, as the coronavirus pandemic-led consumers to search out more inexpensive and convenient ways to feed their families.

As a result, sales have surged.

The shift by tortilla manufacturers toward value-added products began several years ago, but the momentum remains apparent in recent sales figures.

Schroeder, 2021

Product Development Market/Consumer Demand

Introduction

TORTILLAS

A tortilla is a flat, round, unfermented bread produced from wheat flour or lime-cooked maize!

Wheat flour tortillas are more prevalent than maize tortillas throughout the rest of the world out of Central America.

Processing and characteristics of **wheat** flour and **maize** tortillas differ considerably.

Rooney and Serna-Saldivar, 2016

Introduction

WHEAT VS CORN/MAIZE

	Wheat	Corn
Taxonomic family	Triticum	Zea
	Both are belonging to the grass family “Graminea (Poacea)” Grown for their edible seeds	
Origin	Mesopotamia	Mesoamerica
Products	Flour types, semolina, baked goods, pasta products, bulgur, …	Corn starch, syrup, grits, meal, oil, flour, masa, Tortillas, snacks, …
Production (20/21)	773 million tons	1,127 million tons
Constituents	High protein quantity and quality, Gluten!	High carbohydrate, oil

Wheat Flour Tortillas

TYPES OF COMMERCIALLY PRODUCED WHEAT TORTILLAS

Wheat tortillas are produced by three methods: hot-press, die-cut, and hand-stretch. Different types of flours are required for different tortilla processes. Dough preparation and ingredient utilization vary among different operations. Each operation involves a unique dough-forming procedure that then requires specific flour characteristics.

Consequently, tortillas have different properties and end uses.

Bejosano and Alviola, 2015

Wheat flour is the major and most-relevant ingredient used for manufacturing flour tortillas and **the quality of the finished product depends greatly on the quality of the flour.**

Wheat flour requirements are determined by the desired tortilla characteristics, the formula, processing conditions, and equipment.

Wheat Flour Tortillas

Tortilla flour is considered by milling companies to be a specialty type of flour. It is milled for the tortilla industry as a grade separate from bread, pastry, or all-purpose flours.

Enriched, lightly bleached, hard-wheat flour is generally used for tortillas. It is made from proprietary blends of hard red winter wheat.

Bejosano and Alviola, 2015

Hard Red Winter

Versatile, with excellent milling and baking characteristics for wheat foods like hearth breads, hard rolls, croissants and flat breads.

U.S. WHEAT ASSOCIATES

Wheat Flour Tortillas

MAJOR FLOUR CONSTITUENTS AFFECTING TORTILLA QUALITY

Protein Quantity & Quality

Most flour tortillas are made using all-purpose flours containing intermediate protein content of around 11%. The milling operations use wheat blends in order to obtain the most suitable flours for this application.
Flours with stronger protein quality are used in hand-stretch and die-cut tortilla operations, while a wider variety of flours is used in hot-press operations.

A strong-protein flour makes tortillas with smaller diameter but with longer shelf stability.
On the other hand, a weak protein-strength flour makes larger-diameter tortillas that have short shelf stability.
Thus, flour with intermediate protein quality would be appropriate.

Flour protein quality appears to have greater impact on tortilla properties than does protein quantity!

Wheat Flour Tortillas

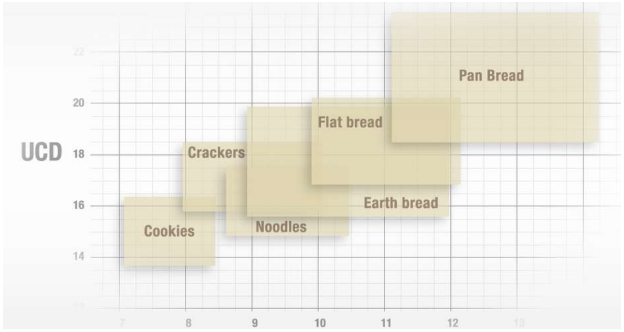
MAJOR FLOUR CONSTITUENTS AFFECTING TORTILLA QUALITY

Starch
Damaged starch, Starch particle size, Amylose content, Retrogradation

Starch damage in flour affects the properties of tortillas. As starch damage increased, flour tortillas becomes less stretchable, and firmness and rollability increases.
To make a tortilla with acceptable rollability, starch damage should not be too high.

Mao and Flore, 2001

For any product, there is an optimum level of starch damage!



Starch damage affects water absorption, stickiness, consistency, flexibility and retrogradation!

Wheat Flour Tortillas

MAJOR FLOUR CONSTITUENTS AFFECTING TORTILLA QUALITY

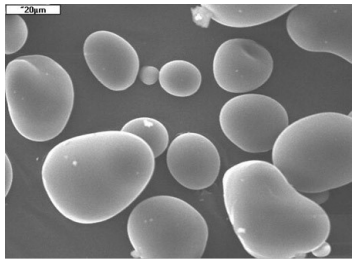
Starch
Damaged starch, **Starch particle size, Amylose content,** Retrogradation

Flours with larger starch granules, were found to produce better tortilla texture.

Mao and Flore, 2001

Flour amylose content greatly affected tortilla textural characteristics.

Guo et al., 2003



Starch affects rollability, appearance (cracks, texture), stickiness, shelf life!

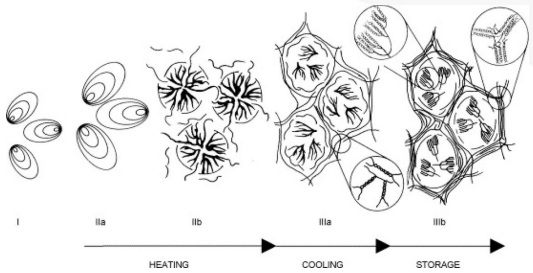
Wheat Flour Tortillas

MAJOR FLOUR CONSTITUENTS AFFECTING TORTILLA QUALITY

Starch
Damaged starch, Starch particle size, Amylose content, **Retrogradation**

After baking, the starch will tend to partially recrystallize. This phenomenon is called retrogradation and explains why the products become hard (stale).

The faster the starch retrogradation, the faster the tortillas will lose its freshness. As a result, flours with slow retrogradation are favored.



Wang et al., 2015

Wheat Flour Tortillas

PHYSICAL DOUGH PROPERTIES/DOUGH RHEOLOGY

The main techniques used for measuring cereal dough properties have traditionally been divided into descriptive empirical techniques and fundamental measurements.

Within the baking industry there is a long tradition of using descriptive empirical measurements of rheological properties, with instruments such as the Penetrometer, Texturometer, Consistometer, Amylograph, Farinograph, Mixograph, Extensograph, Alveograph, Mixolab various flow viscometers and fermentation recording devices.

They have provided a great deal of information on the quality and performance of doughs such as consistency, hardness, texture, etc.

Dobraszczyk, 2020

Wheat Flour Tortillas

PHYSICAL DOUGH PROPERTIES/DOUGH RHEOLOGY

Water Absorption: Tortillas require less water compared to bread doughs.
Water absorption affects; Size & Shape, Appearance (Pillowing), Stickiness (Overhydration), Shelf Life!

Mixing Time: Tortillas require less water compared to bread doughs.
The under-and overmixing modify dough texture, gluten development, and tortilla quality.
Mixing time affects; Size & Shape, Appearance, Stickiness, Shelf Life!

Extensibility: Extensibility is the capacity of the dough to be stretched without breaking.
Extensibility affects; Size & Shape, Appearance!

Wheat Flour Tortillas

PHYSICAL DOUGH PROPERTIES/DOUGH RHEOLOGY

Elasticity: Elasticity is the tendency of the dough to return to its initial position after its shape is distorted, such as by pressing.
Elasticity affects; Size & Shape, Appearance!

The rheological properties of dough determine its behavior during dividing, rounding and molding, as well as the quality of the finished products!

Wheat Flour Tortillas

PHYSICAL DOUGH PROPERTIES/DOUGH RHEOLOGY

A Mixolab Study

"The Mixolab profiler showed that a good flour for hot-press tortillas had a relatively lower absorption and short dough mix time compared with a bread flour and should have a significantly higher gluten compared with an all-purpose flour.

Compared with bread flour, the tortilla flour had higher retrogradation and viscosity values.

The Mixolab profiler proved to be a good preliminary test to evaluate flours for hot-press tortillas.

This instrument showed that the best performing flours had a relatively lower absorption and short dough mix time compared with bread flour and a high gluten profile within the category of all-purpose flours."

Posner et al., 2014

Wheat Flour Tortillas

TORTILLA QUALITY

The ultimate measure for determining the baking performance of flours for tortillas is the baking test.

- Good quality tortillas are symmetrical, uniform and opaque with toasted spots!
- They should also be soft, flexible without cracking when folded, and puffed!
- Good quality wheat flour tortillas usually have large diameters (17-18 cm) and more than two weeks of shelf stability!

de Barros, 2009

Good-quality tortillas have been defined as tortillas that are symmetrical, uniform, opaque, toast-marked, puffed, soft, flexible without cracking, and having a long shelf life.

Brooker, 2015

Diameter, thickness, weight, specific volume, moisture, rollability, flexibility, appearance (crack/break, blisters), pillowing, color, opacity, firmness, …!

Product Inspection

EXAMPLES **Tortilla, Flat Bread, Pizza Crust**

PRODUCTS

Corn/Flour Tortilla, Flat Bread, Pizza Crust

LINE CONFIGURATIONS

Line Width: 900-2300mm

Throughput: up to 1500pcs/min

SYSTEM MODULES

Top Side Inspection (Color & 3D)

Bottom Side Inspection (Color)

Automatic Learning

Real Time Statistics

Data Collection & Reporting

Pneumatic Rejection System

Hygienic Stainless Steel Frame

MEASUREMENT CAPABILITIES

2D/Shape (diameter, roundness)

3D/Height (peak, mean, slope)

Bake Color (Lab & BCU)

Topping/Toast Marks Conformity

Rim Conformity

DEFECT DETECTION CAPABILITIES

Misshapen products

Edge Defects (bites, straight edge)

Out of spec (e.g. small, too dark …)

Spots (light, dark, foreign mat.)

Topping defects (e.g. voids)

Holes

EyePro System products are leading the effort for incorporating vision technology in the baking and snack food industry.

ON-LINE measures for each product

SHAPE/2D CONTROL

LENGTH / WIDTH

DIAMETER / AREA

ASPECT / EDGES

BITES / TAGS

HOLES BURNT SPOTS

OVERLAPPING PRODUCTS

ROUNDNESS

FULL COLOR ANALYSIS

CIE-LAB OR BCU

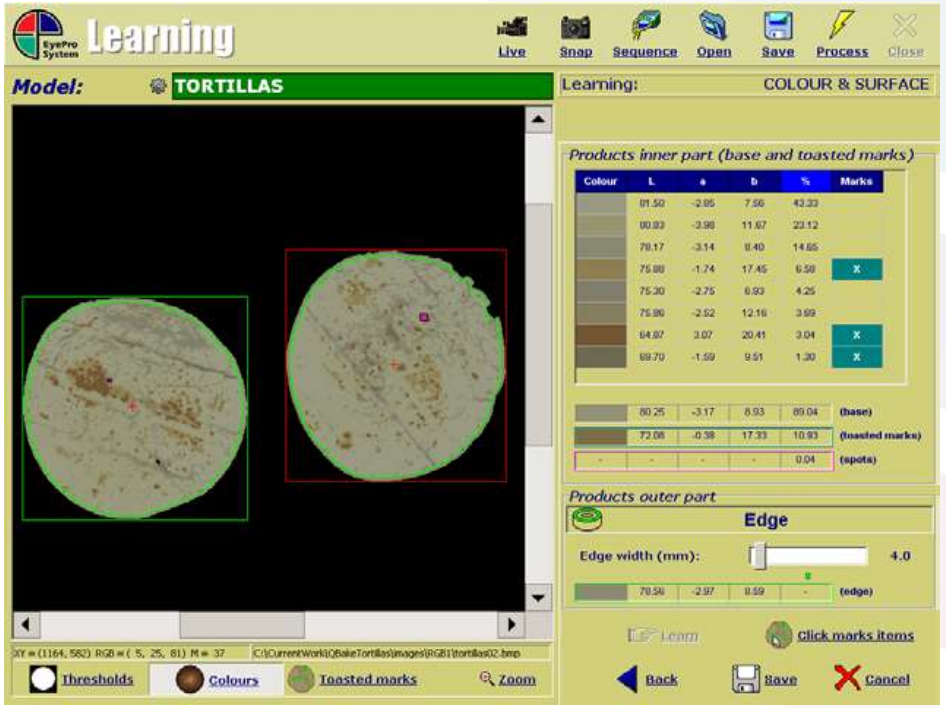
BAKE COLOR INTENSITY (MEAN/EDGE/CENTRE)

TOPPING (COLOR/DISTRIBUTION)

BURNS / RESIDUES

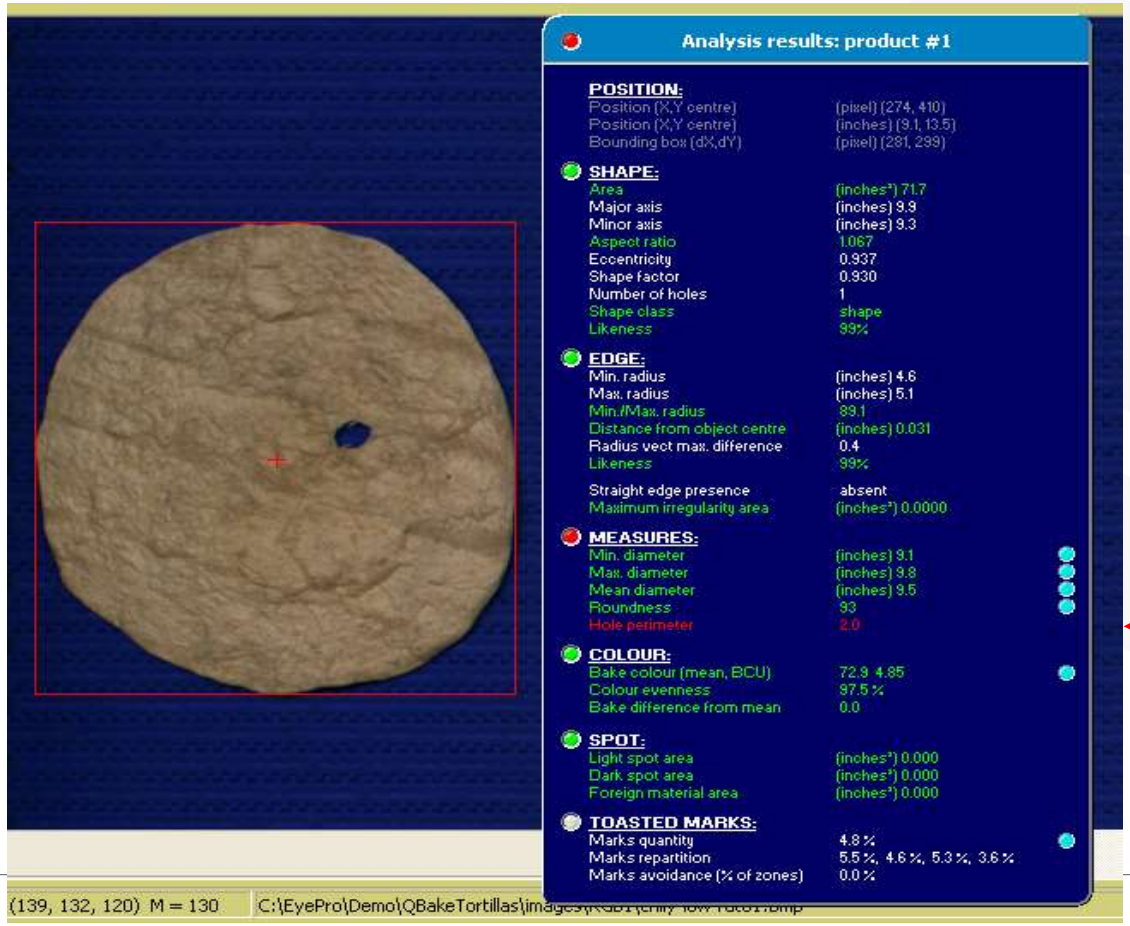
SPOTS / HOLES

SURFACE DEFECTS (TEXTURE)



Software Features

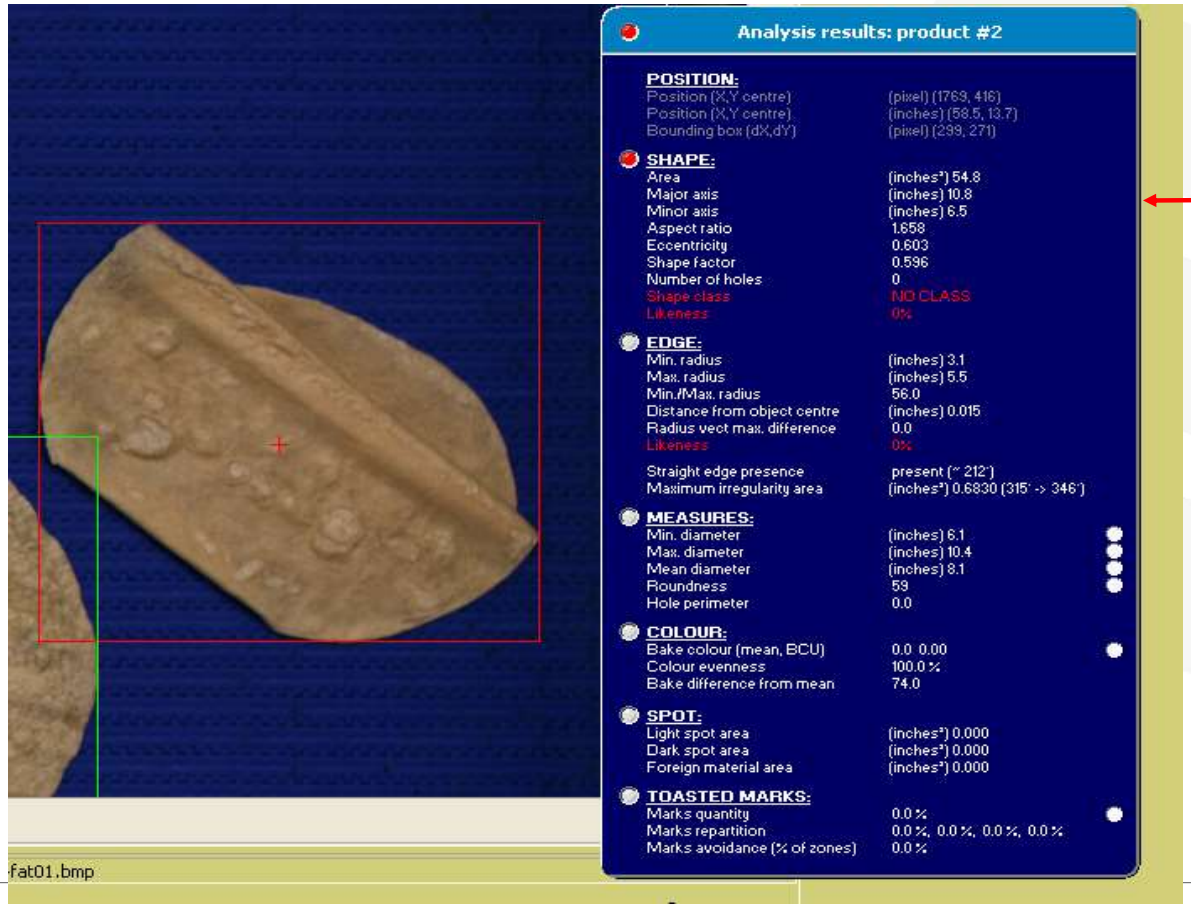
Defect detection and automatic rejection



HOLE DEFECT

Software Features

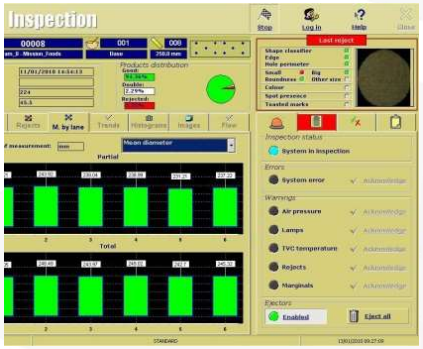
Defect detection and automatic rejection



MISSHAPEN PRODUCT

Vision Technology used to automatically adjust process equipment

Example on Tortilla applications



Automatic Process Control

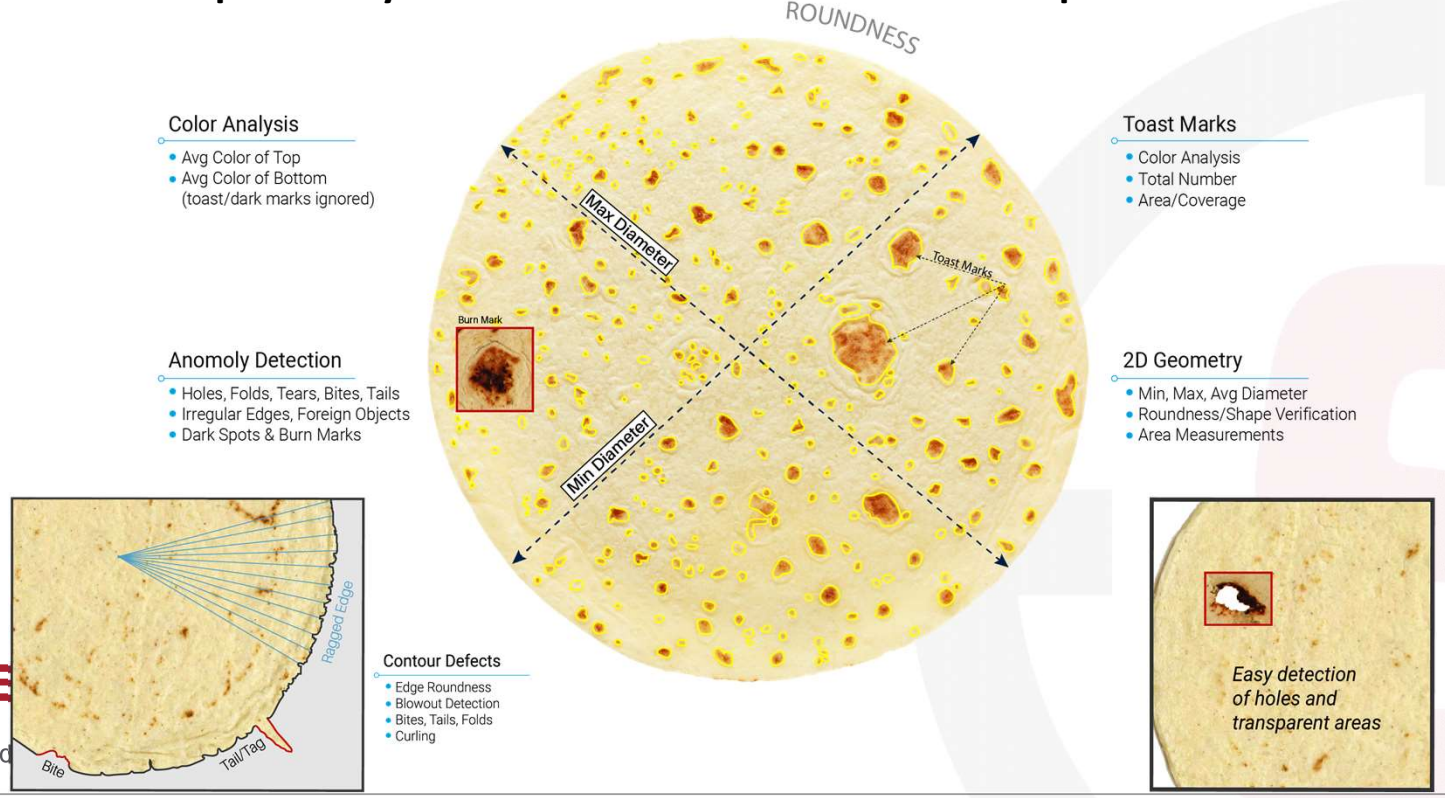
Flour tortilla

- Vision System measures product diameters and automatically adjust the press settings
- Improved product size consistency
- Waste reduction

Vision Inspection Systems

Tortilla Measurements

Sightline Process Control products are specialized, 3D color vision technologies used in inspection systems and automation solutions for process control.



Color Analysis
- Avg Color of Top
- Avg Color of Bottom (toast/dark marks ignored)

Anomoly Detection
- Holes, Folds, Tears, Bites, Tails
- Irregular Edges, Foreign Objects
- Dark Spots & Burn Marks

Contour Defects
- Edge Roundness
- Blowout Detection
- Bites, Tails, Folds
- Curling

Toast Marks
- Color Analysis
- Total Number
- Area/Coverage

2D Geometry
- Min, Max, Avg Diameter
- Roundness/Shape Verification
- Area Measurements

SIGHTLINE a KPM ANALYTICS brand

Corn Tortillas

TYPES OF COMMERCIALLY PRODUCED WHEAT TORTILLAS

Lime-Cooked Maize Products

Three basic types of products are industrially produced from lime-cooked maize: table or soft tortillas, corn chips, and tortilla chips.

Corn and tortilla chips are primarily produced and consumed in developed countries, where they have an important share of the salted snack-food market.

Modern production of tortilla chips and corn chips has evolved into specialized processes. They are quite different from the original tostadas made by frying stale, maize table tortillas.

Rooney and Serna-Saldivar, 2016

Corn Tortillas

MAJOR CORN CONSTITUENTS AFFECTING TORTILLA QUALITY

The types of corn

Corn is classed according to color and kernel configuration into yellow or white and dent or flinty.

White, yellow, and blue corns are processed into tortillas and chips in the United States and Mexico.

The main criteria used to select corn for the manufacturing of tortillas and related snacks are related to their physical properties because they affect chemical composition, functionality, processing parameters, and end use. The preferred corns should be medium to large sized (290–340 g/1,000 kernels) and possess a round crown, a smooth dent, an intermediate endosperm texture, an easily removable pericarp, a clean bright white or yellow color, and a kernel with tolerance to damage during handling.

Whole, sound, mature kernels of maize with a high proportion of hard to soft endosperm yield more masa and tortillas after nixtamalization!

Corn Tortillas

MAJOR CORN CONSTITUENTS AFFECTING TORTILLA QUALITY

The types of corn

Table tortillas are preferably manufactured from dent white maize, although yellow kernels are also used or blended with white kernels before cooking. The grain's physical properties play the main role in the quality of table tortillas and related products because they affect processing parameters and influence end-product features.

The main quality control parameters for fresh masa and dry flours are particle size distribution, water absorption, water solubility, viscosity, color, and pH. Likewise, the principal quality measurements for wheat flour tortillas are dough rheological properties determined with the Farinograph, Alveograph, Mixolab, and related instruments.

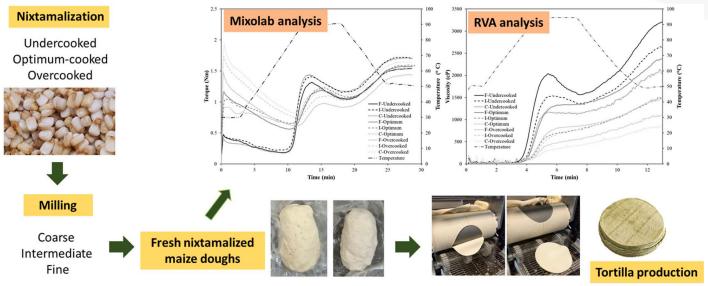
Brooker, 2015

Corn Tortillas

MAJOR CORN CONSTITUENTS AFFECTING TORTILLA QUALITY

Assessment of the quality of fresh nixtamalized maize doughs

Mixolab discerns among different degrees of cooking in nixtamalized maize doughs (NMD),
The milling degree did not affect the Mixolab profile,
Mixolab parameters were strongly correlated with starch damage in NMD,
Mixolab showed more correlations with starch and tortilla features compared to RVA,
Mixolab resulted an adequate method to evaluate the quality of fresh NMD!



Johanan et al., 2021

Corn Tortillas

CASE STUDY – CORN TORTILLA

Partnership with a tortilla manufacturer:

- The partner is making tortilla from nixtamalized corn masa,
- Difficulties are often faced during the process,
- They appear to be linked to the corn masa's quality,
- The Mixolab can be used with sampled doughs thanks to the dough kit

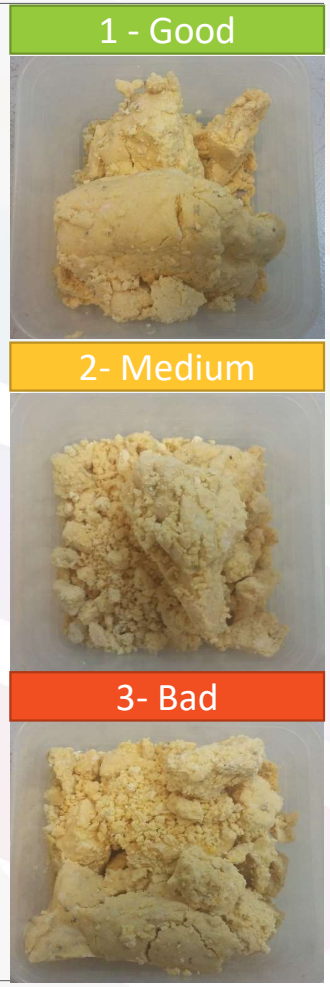
3 samples of various quality (different milling procedures) were tested

Objectives :

Check if the Mixolab is able to analyze corn masa.
Is there a signal?, Is it repeatable?, Is it discriminant?

If yes, is the Mixolab able to classify samples according to their qualities?

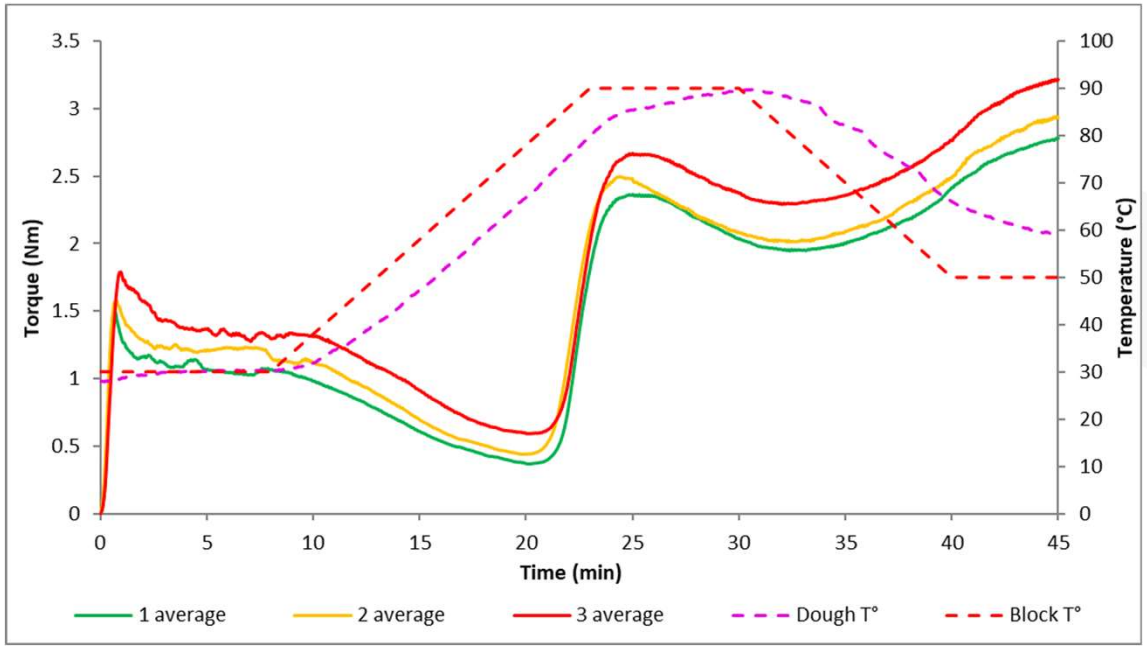
Bosc-Passive, 2021



Corn Tortillas

CASE STUDY – CORN TORTILLA

- ✓ A clear signal is detected, the curves are complete
- ✓ The repeatability curves are well overlaid
- ✓ In general, the lower the torque, the better the masa.



Torques Cs, C3 and C4 allow to classify efficiently the different qualities of doughs in a discriminative way.

When the dough is heated, the lower the torques, the better the sample is according to the process performances

Discrimination OK ! Feasability confirmed!

Bosc-Passive, 2021

Tortilla Quality

	NIR	SD MATIC	SRC-CHOPIN	ALVEOLAB	MIXOLAB
Size & shape			++ absorption	+++++ Extensibility/Elasticity	+++ Hydration
Rollability	+ content	+++ High level	++	+++++ Protein quality	++++ Amylase, starch damage
Appearance			+++ Damaged starch	+++++ Protein on crack, edges, pillowing, exture	+++++ Starch properties action on Cracks and texture
Stickiness	+ content	++ High level	++ High level	+++ Protein quality	++++ Starch properties, hydration
Shelf Life	+ content	+++ High		++++ Protein quality	+++++ Starch properties and damaged starch
Ingredient evaluation				+++++ Ready	+++++ Ready
Work on complete formulas				+++++ Ready	+++++ Ready
Work on dough coming from production line				++ Possible	+++++ Ready

Conclusion

While the tortilla quality depends on other processing variables and the formulation that the manufacturer uses, since wheat flour is the significant and most relevant ingredient used for manufacturing flour tortillas, its quality dramatically affects the final product quality.

Likewise, for corn tortillas, the quality of maize for alkaline cooking is critically important to produce high-quality products.

Conclusion

The objective methods are reliable, sensitive, and time-saving and replace subjective measurements.

In the baking industry, various objective methods are used to characterize the rheology of wheat flour dough and final products. These objective measurements characterize the rheology of wheat flour dough and tortillas.

There is a need to develop standard approved predictive quality tests for tortillas! In addition, there is a need to develop wheats with improved functionality for the tortilla and flatbread market!

Global Leader in Analytical Instrumentation

KPM Analytics enables companies in agriculture, food, and related industries to effectively manage quality and protect value of their brands

Summary Highlights

- Established in 2015, HQ in Boston, MA, USA
- 7 strong brands located in four countries
- Long term partnership with blue chip customers in various industries around the world
- Wide product range for R&D, quality control and process optimization
- ~50 patents granted or pending, ~40 trademarks
- Global applications experts with decades of experiences
- Over 15,000 Installs in 100+ countries
- 14 direct sales & service offices globally
- Over 200 sales and service distribution partners worldwide

Industries

Agriculture

Food & Beverage

Feed, Forage & Animal food

Environmental Testing

Clinical Diagnostics

Industrial Manufacturing

KPM Brands

Unity Scientific

CHOPIN TECHNOLOGIES

AMS Alliance

Sensortech Systems

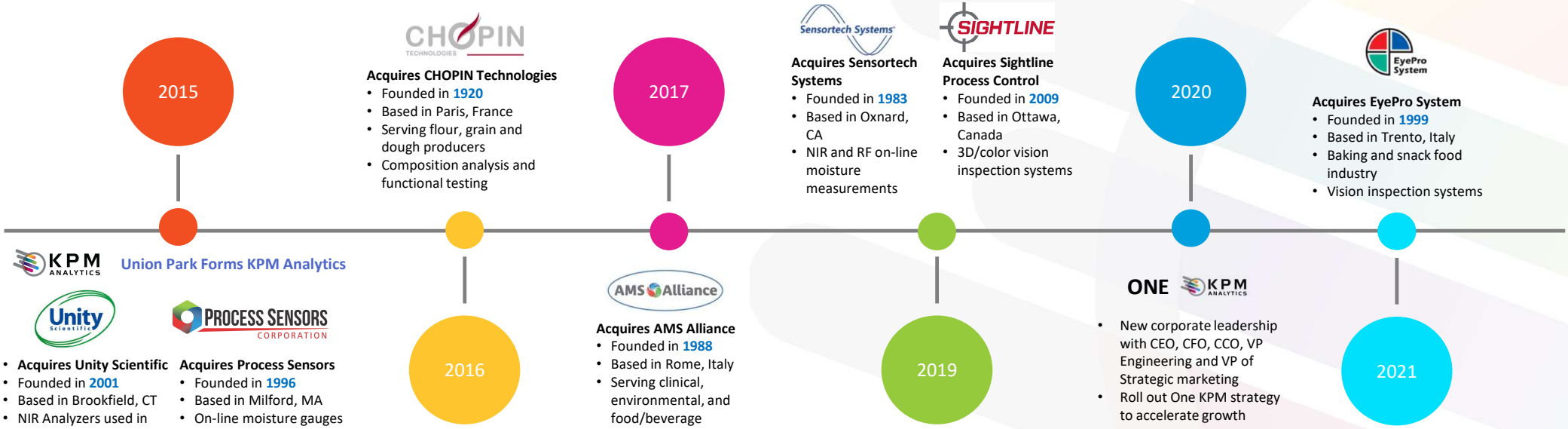
PROCESS SENSORS

SIGHTLINE

EyePro System VISION TECHNOLOGY

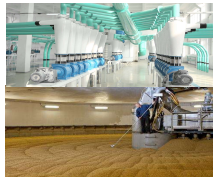
Timeline and Progression of KPM Analytics

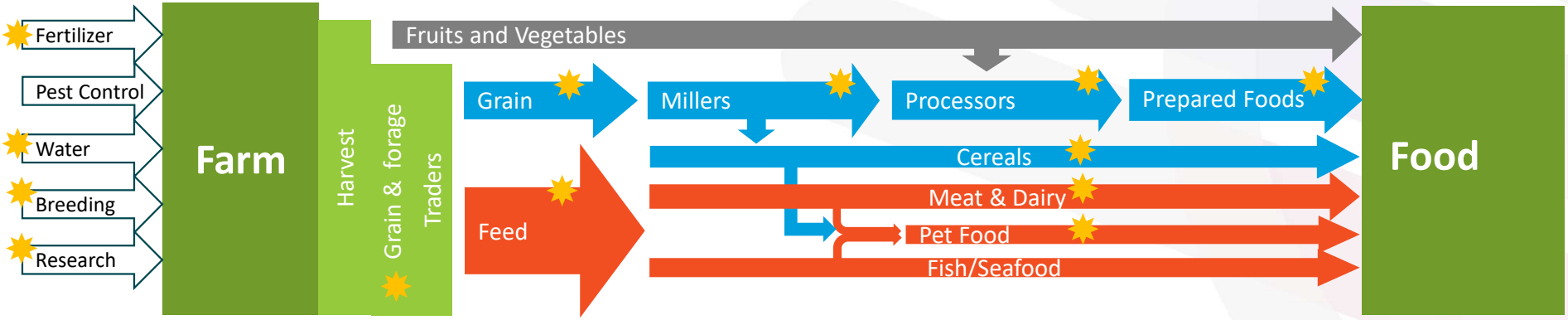
KPM Analytics brands have long and successful histories servicing customers worldwide



Impacting Quality Across the Entire Value Chain

From raw ingredients to prepared foods, our products rapidly assess critical properties and overall quality





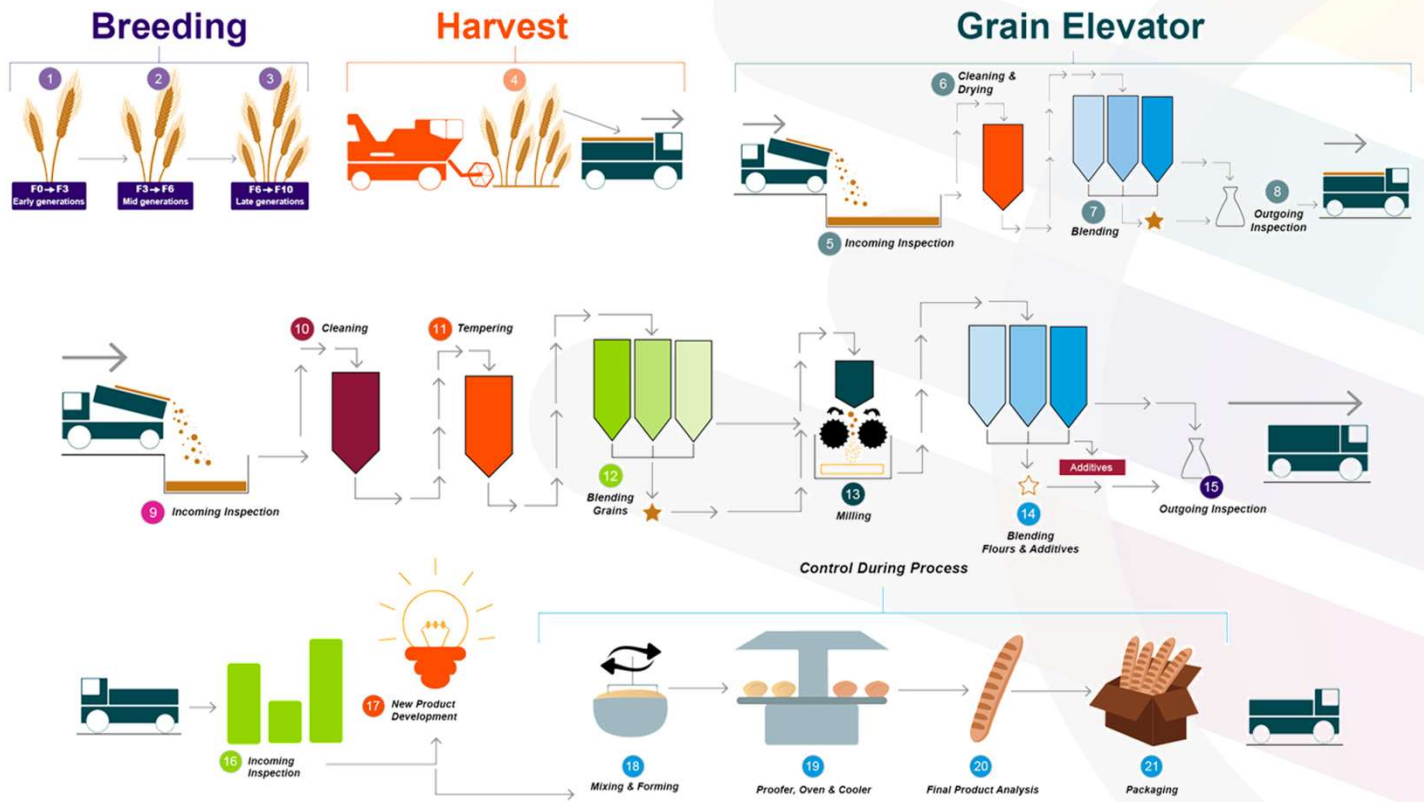
Trusted Partner Supporting Every Step of the Food Production Process

KPM brand solutions are used in every process step throughout the grain, milling and baking supply chain

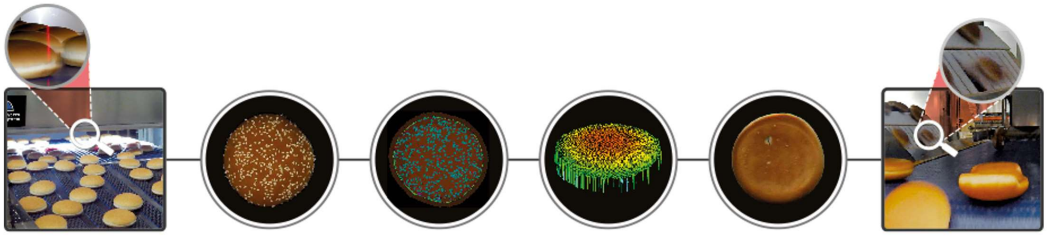
Breeding Through Elevator

Milling

Baking



CHOPIN Technologies is a brand of KPM Analytics



Unity Technologies
PROCESS SENSORS CORPORATION
Sensortech Systems

NIR & RF moisture and compositional analysis for various industries

CHOPIN TECHNOLOGIES

Functional & rheological analysis for grain, flour and dough

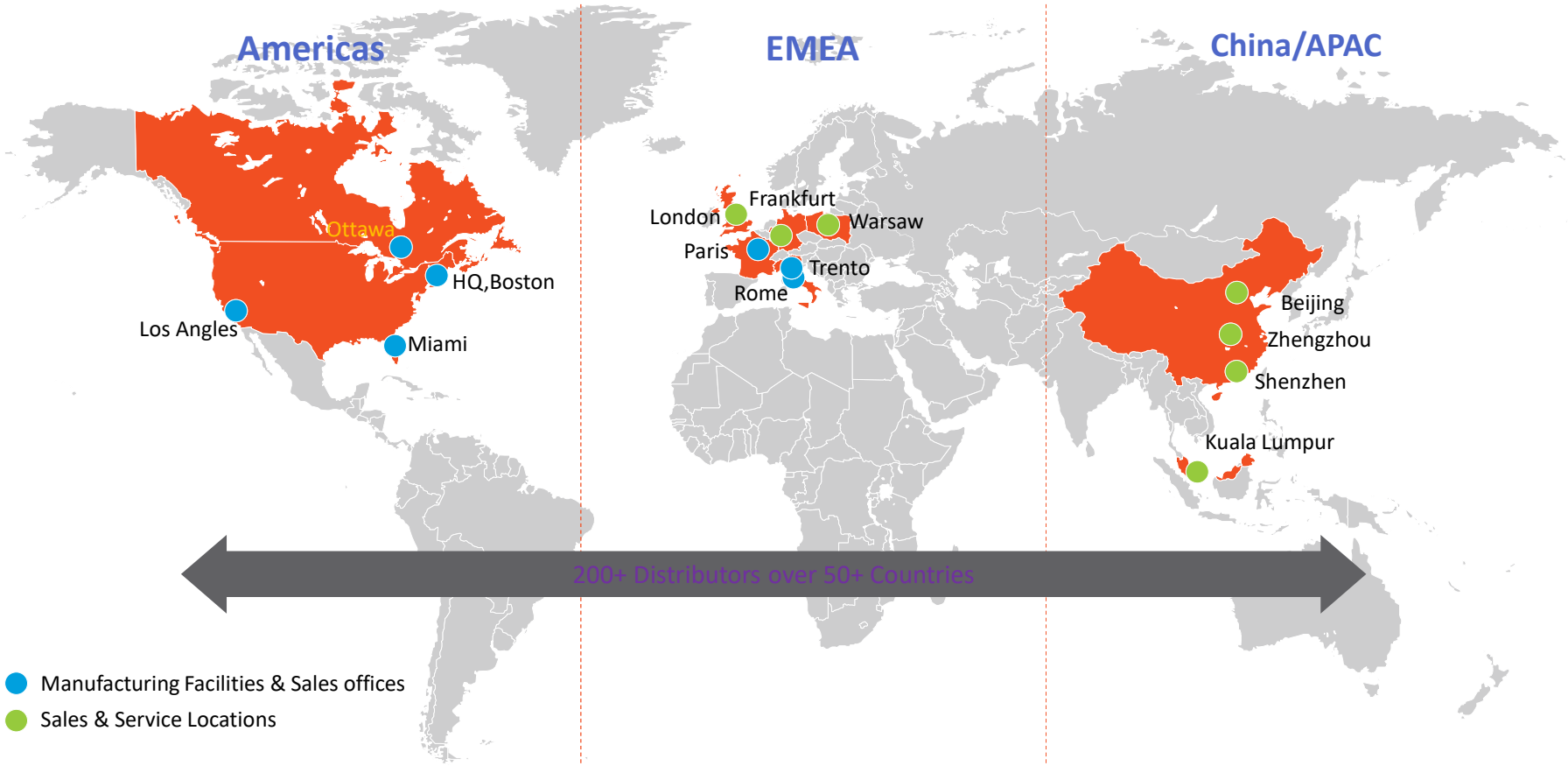
AMS Alliance

Wet chemistry analysis for agriculture, food, environmental and clinical applications

EyePro System
SIGHTLINE

Machine vision inspection for food production and packaging lines

Extensive Global Sales and Service Network



THANK YOU FOR YOUR ATTENTION
ANY QUESTIONS ?

hboyacioglu@kpmanalytics.com