Effect of damaged starch on wheat flour tortilla quality

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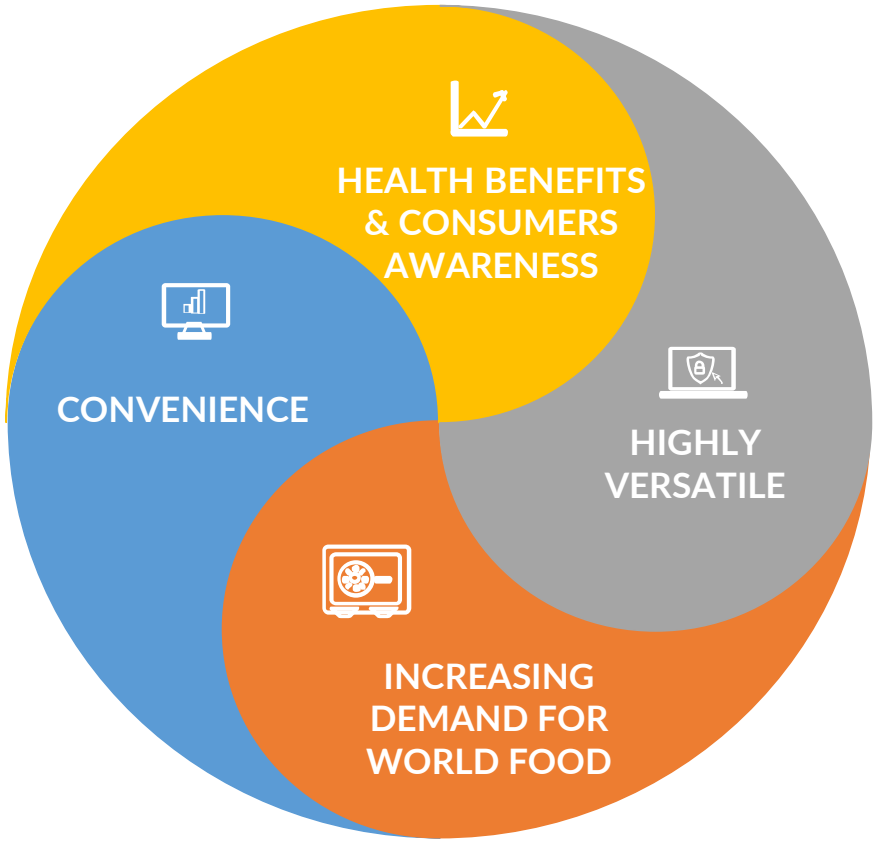
Tortillas – A Universal Pleasure



- Increasing demand for convenient food
- May be used as a bread replacement

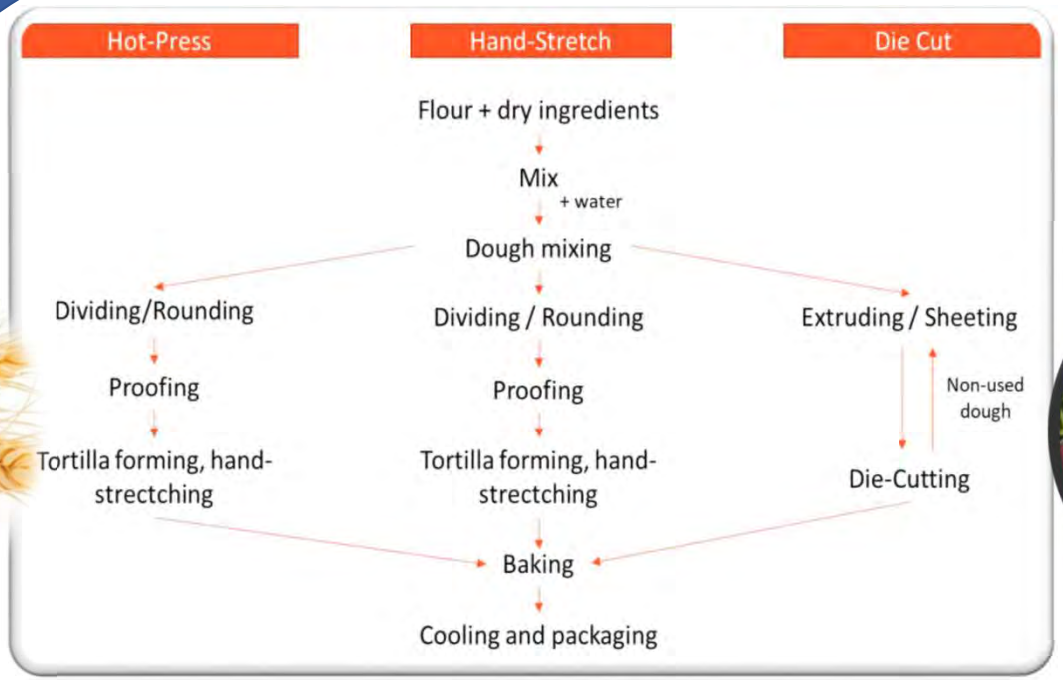
- Low in carbohydrates
- Rich in minerals, vitamins, and proteins

- Many possibilities, adapted to specific diet (GF, vegan,…) or requirements (organic, clean label)

- People are looking to increase the diversity of their meal
- Example: Pizza is the favorite dish in the world, Tortilla arrives at Position 10 after Croissant and Ramen – *Source: Taste Atlas*

Baking is a Transformation Process

Transforming this…



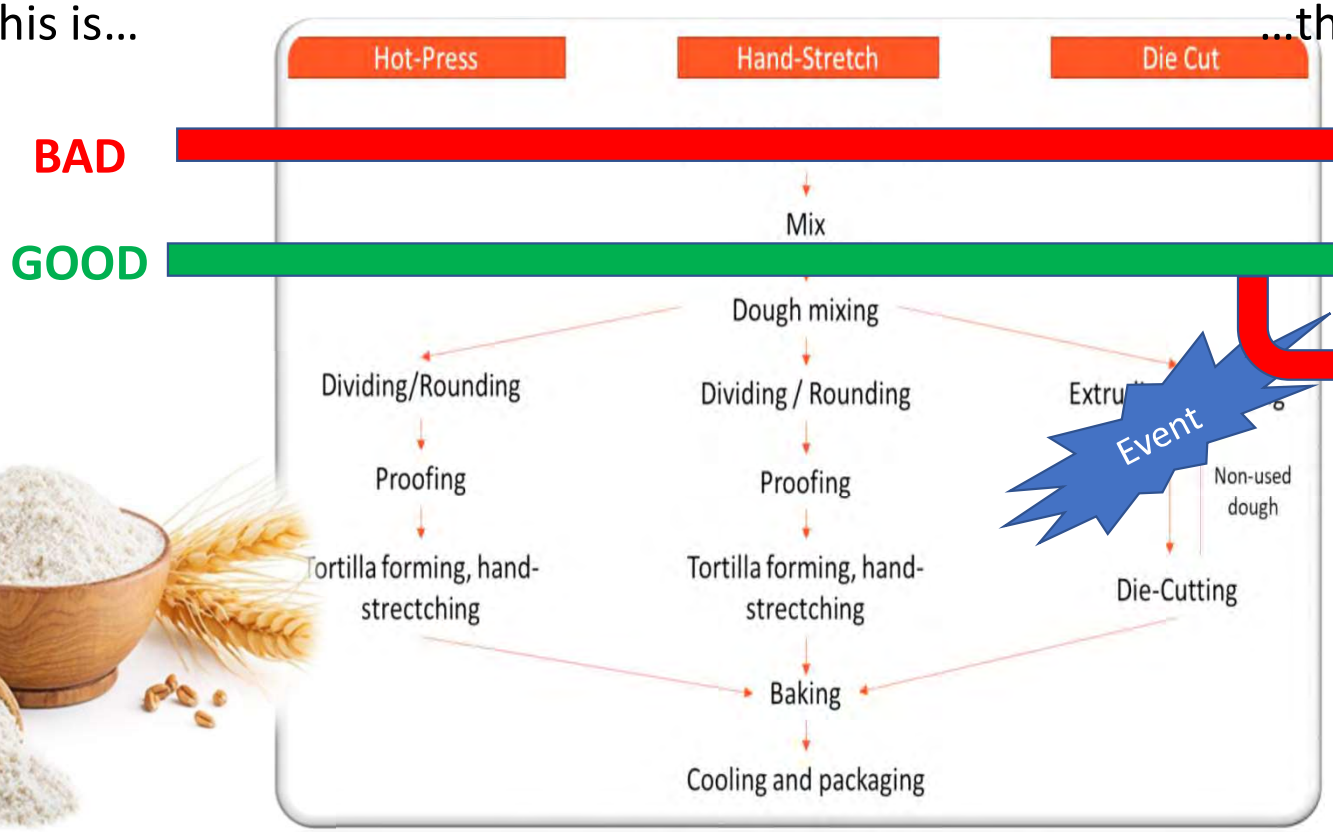
…into this.

Bosc-Bierne, TIA Europe Conference 2023

Potential Influence of Raw Material Quality (Flour)

If this is…

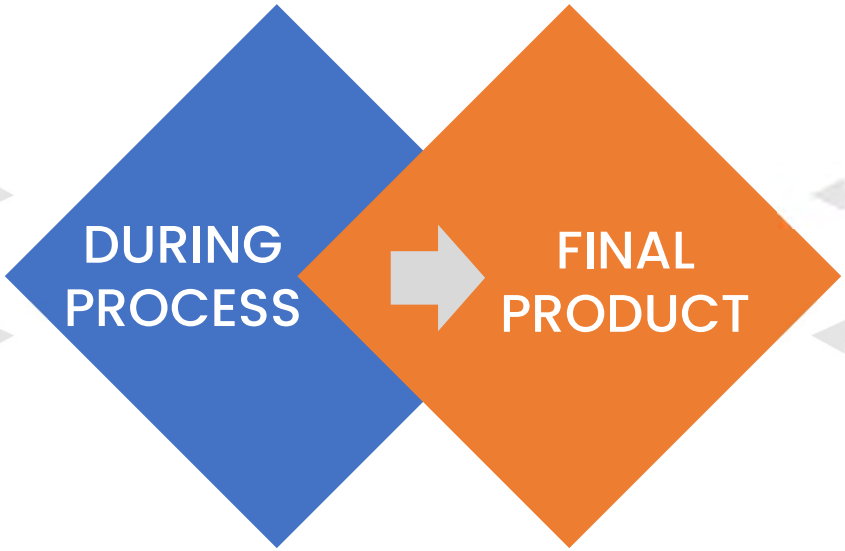
…this will most probably be



Main Technological Challenges

WATER ABSORPTION capacity must be controlled to reach the right CONSISTENCY without excessive STICKINESS.

The dough must be sufficiently EXTENSIBLE so that it does not break, and NOT VERY ELASTIC so that it does not shrink after cutting.



The final product must have the good SHAPE, THICKNESS and COLOR. Conform ROLLABILITY and FOLDABILITY are required.

No DEFECT should be visible : No CRACKS nor PILLOWING

+ SHELF LIFE is a key parameter.

Bosc-Bierne, TIA Europe Conference 2023

Main Technological Challenges

- There are many different types of tortillas and great variation in manufacturing processes!

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.

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

Bejosano and Alviola, 2015

Main Technological Challenges

Selecting the right flour requires careful consideration because ***protein*** and ***starch properties*** that cause longer shelf stability are the same factors that make tortilla diameter smaller.

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.

Both protein content and strength of flour show negative correlations with tortilla diameter.

Nevertheless, the quality of the end product also depends on other processing variables and the formulation that the manufacturer uses.

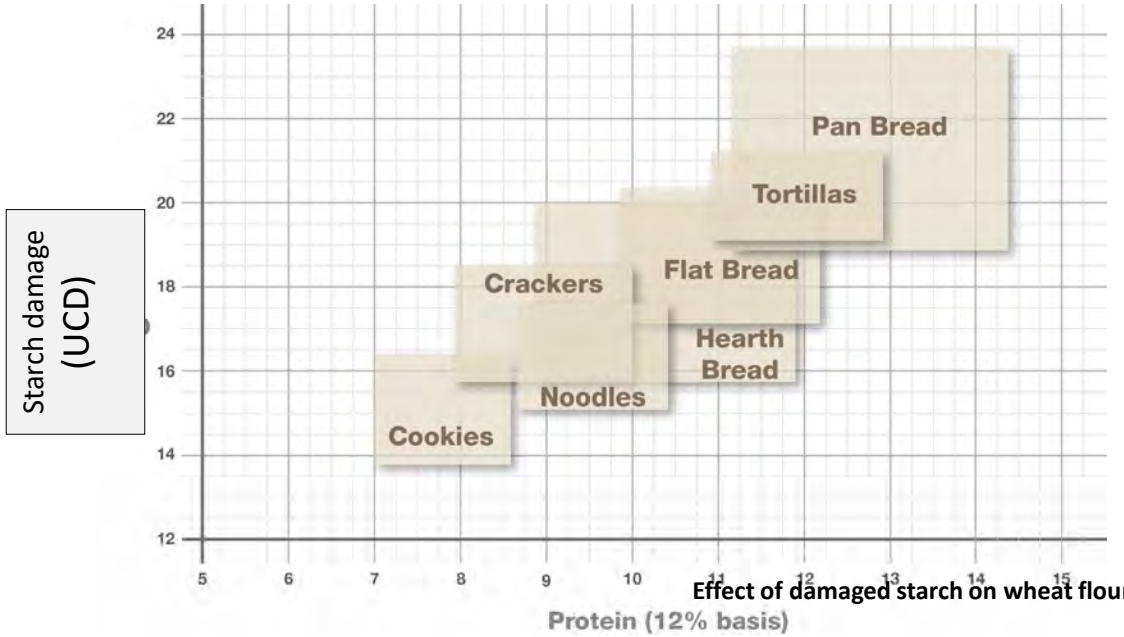
Bejosano and Alviola, 2015

Main Technological Challenges

Starch damage in flour affects the properties of tortillas.

Wheat flours with a low damaged starch content are reported to produce tortillas with a larger diameter and a better texture than those with a high damaged starch content.

There is an ideal level of *damaged starch* according to the level of proteins and the ideal area for accepting incoming flours should be defined.



Effect of damaged starch on wheat flour tortilla quality

Main Technological Challenges

Starch damage

- When starch damage occurs at low levels (or at optimum/moderate levels for the desired product) of the total wheat starch, they are considered to be beneficial to flour performance;

  because they are readily accessible to water and enzyme penetration and serve the dual function of increasing flour absorption and providing fermentable maltose for the yeast.

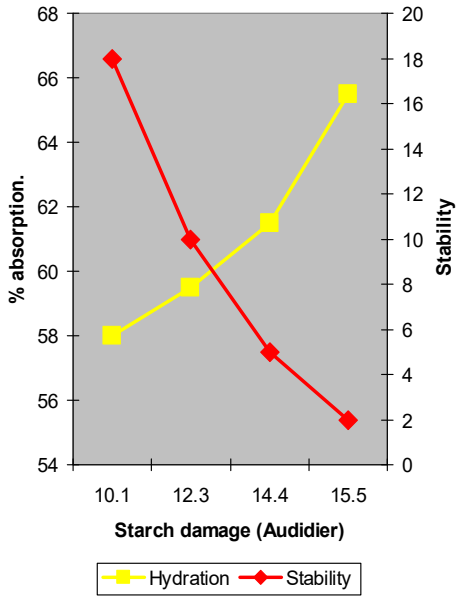
Main Technological Challenges

Starch damage

EFFECTS ON WATER ABSORPTION

- Protein absorbs 1.8 times its weight of water,
- Pentosans: 10 times,
- Native starch: 0.4 times,

Damaged starch: 3 to 4 times!



MILLERS' OBJECTIVE

- Produce the largest amount of flour from a lot of wheat (economic profitability)
- Produce flours according to the specifications of their customers (high hydration capacity flours for example for bread making flours)

BAKERS' INTEREST

- Add max content of water (better yield and better profit)

Main Technological Challenges

Starch damage

EFFECTS ON DOUGH PROCESSING

- Doughs produced with high mechanical starch modification levels may not be fully developed at Peak time (optimum mixing time) and display a second peak – Modify mixing time?
- Possibility of having a sticky dough probably because of weakened protein–filler interfacial interactions and larger voids within the protein network?

Hackenberg, et al., 2019

- Damaged starch increases initial water absorption and prevents optimum gluten formation during mixing!!!

Effect of damaged starch on wheat flour tortilla quality

KPM

Why do we measure starch damage?

Starch damage

EFFECTS ON STALING/SHELF LIFE OF THE BREAD

The **content of damaged starch** also influences the bread staling through **increasing the retrogradation of the amylopectin and crumb firmness**, and therefore affects negatively the quality of the resulting fresh products and their shelf life.

Le´on, et al., 2006

Effect of damaged starch on wheat flour tortilla quality

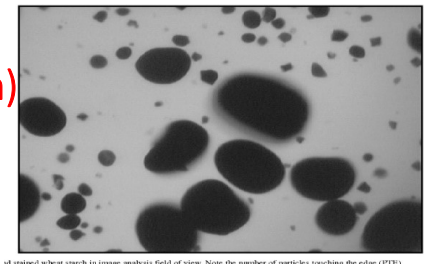
Main Technological Challenges

What is damaged starch?

Structurally disruption/modification of starch granules in wheat and flour!

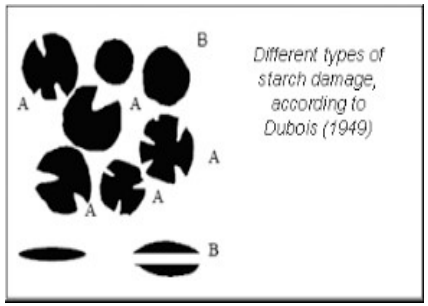
Starch damage, damaged starch, mechanically activated starch, mechanical starch modification

Small, Round (B-starch)

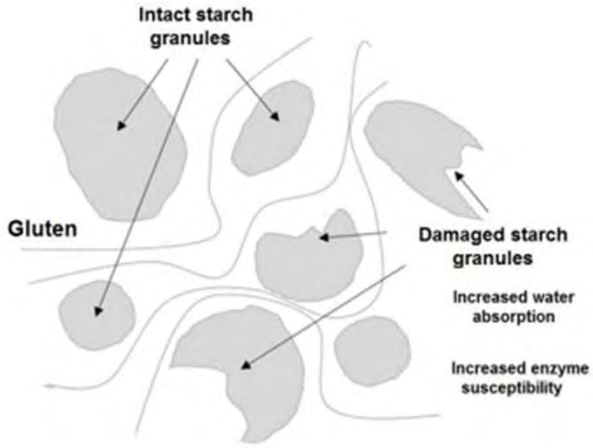


(Wilson, et al., 2006)

Large, Lenticular (A-starch)



Different types of starch damage, according to Dubois (1949)



Main Technological Challenges

Where does it come from ?

There are two types of starch damage:

- *Damaged starch comes from the wheat itself (as a function of hardness) - genetic criteria –*

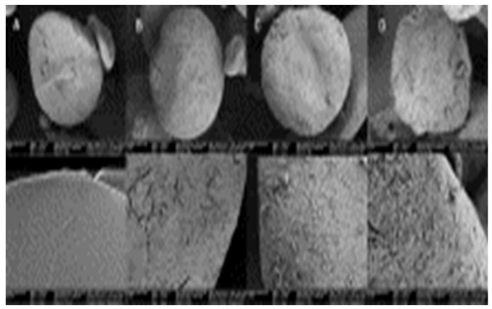
The first is that which results in the starch granule being broken in two. Although the granule is clearly damaged, this type of damage results in starch that is not susceptible to attack by fungal α-amylase.

Main Technological Challenges

Where does it come from ?

- *Damaged starch also comes from the milling process - mechanical criteria -*

The second more classic starch damage produced during milling results in granules that have partially or completely lost their crystallinity and are susceptible to fungal α-amylase.



Barrera, et al., 2013

Main Technological Challenges

Starch damage during milling

- Roller milling damages a small but significant number of the starch granules in the flour.

In general, the level of damage depends not only on the hardness of the wheat used but also on the settings of the milling rolls. Indeed, given a constant wheat supply, flour with increasing water-absorption characteristics can be produced by adjusting the roll settings such that increasing levels of starch damage are produced.

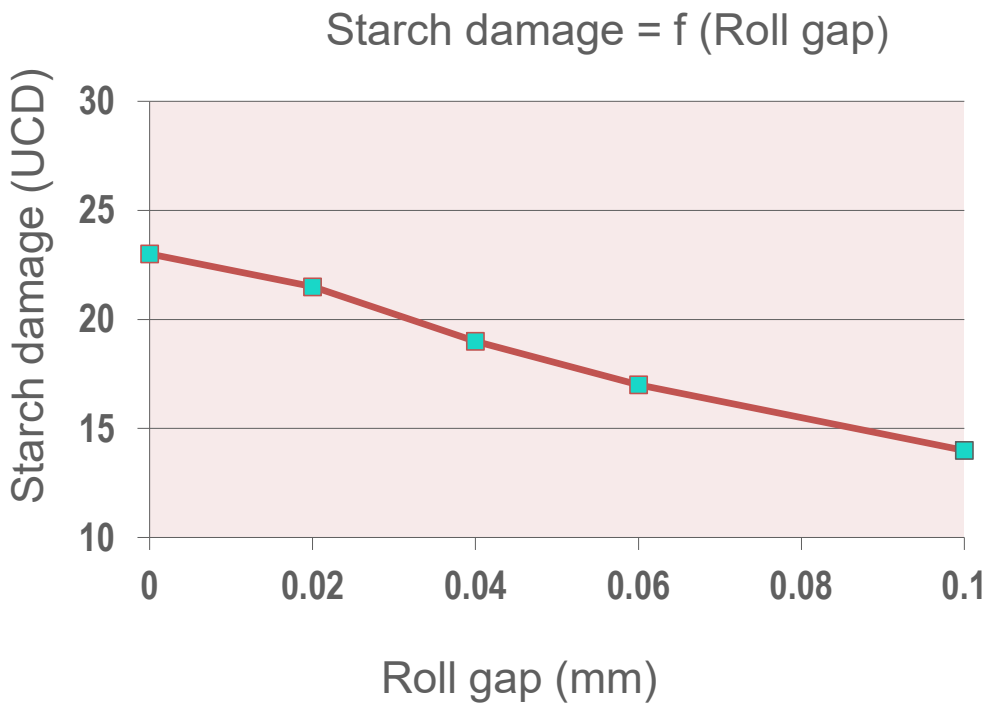
Hard

Soft

Main Technological Challenges

Starch damage during milling

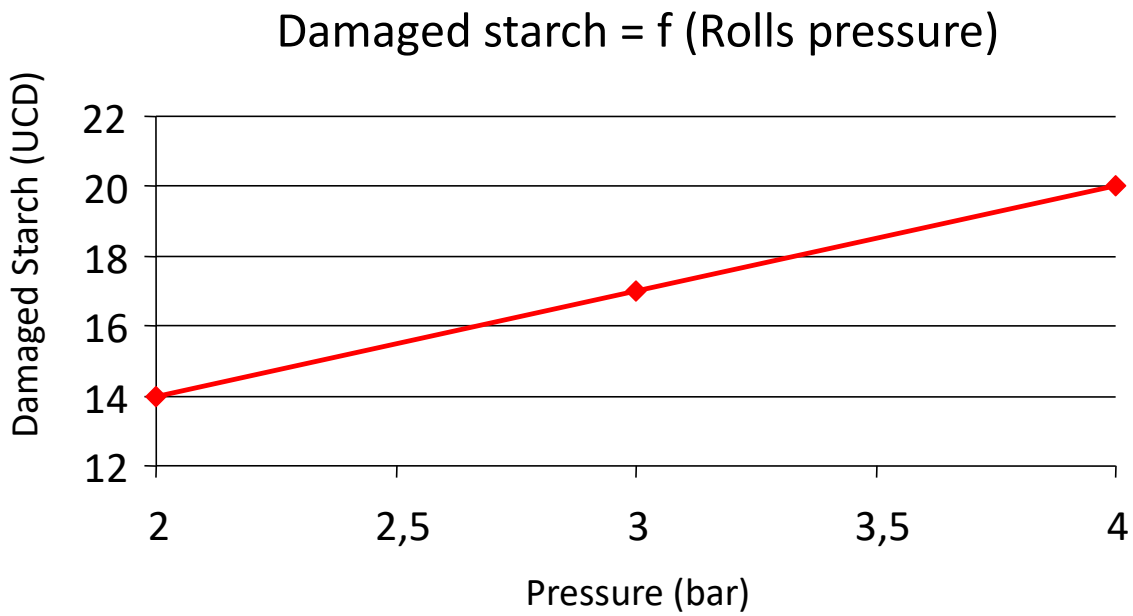
Impact of roll adjustments



Main Technological Challenges

Starch damage during milling

Impact of roll adjustments



Impact of flour type and damaged starch content on tortilla quality parameters

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Kansas State University

Objective

- To assess the impact of mechanically damaged starch on processing and quality attributes of flour tortillas!
  - Hard and soft wheat

Materials and Methods

Flours

- Hard Red Winter Flour, 10.9% protein
- Soft Red Pastry Flour, 8.2% protein

Pin milling

- Alpine Ausberg Mill
- 0 - 7 passes

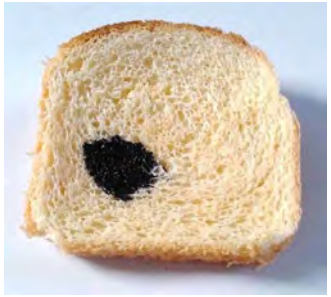
Characterization

- Damaged Starch (SDmatic)
- Absorption (Farinograph)
- Moisture Content (NIR)

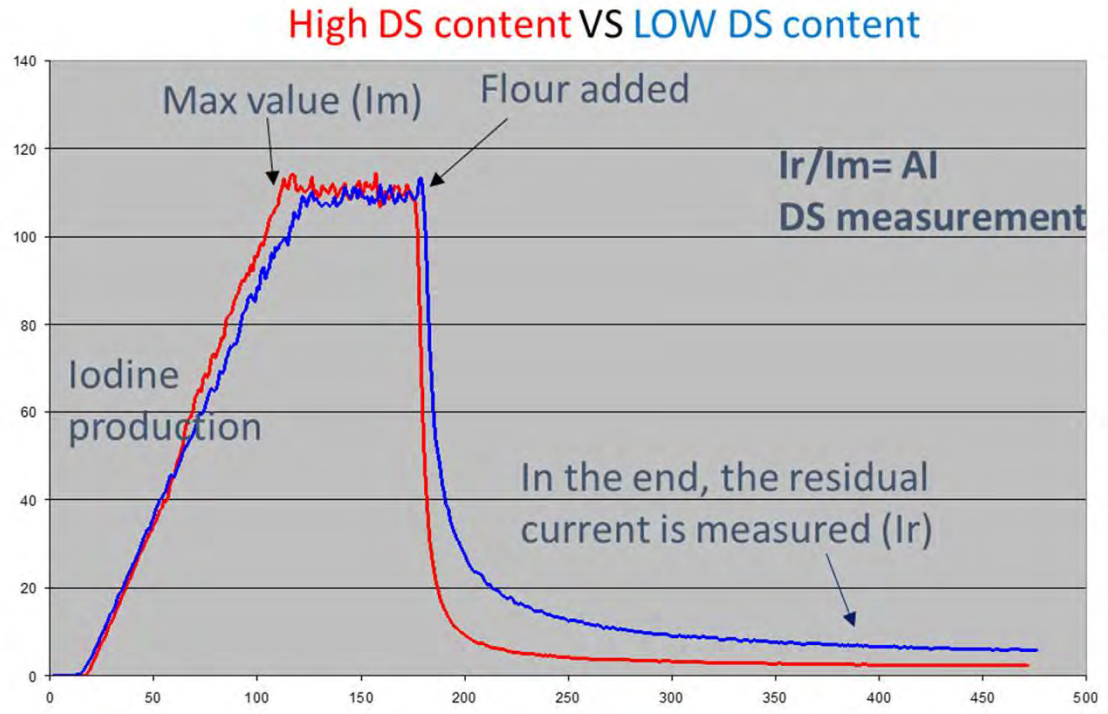
Materials and Methods: Damaged Starch Determination

AACC 76-33.01 Damaged Starch — Amperometric Method by SDmatic

- *Based on the measurement of iodine absorption, it works on 1 gram of flour and provides results in only 10 minutes.*



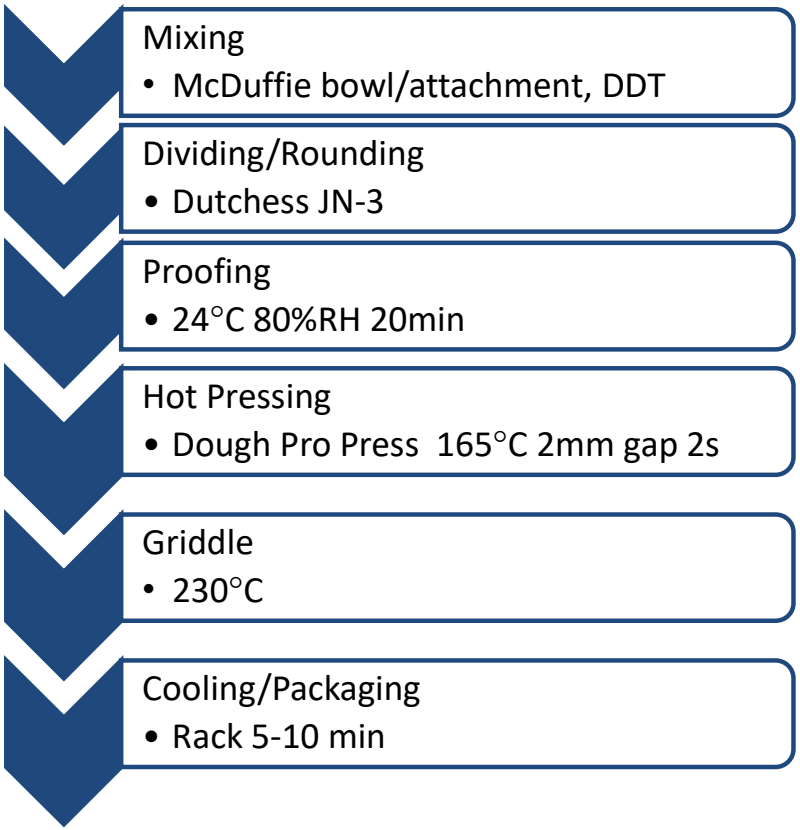
1. Preparation of an iodine solution.
2. Iodine creates an electrical flow.
3. When the iodine fixes on the damaged starch, the intensity of the current decreases.
4. The less intense the electrical current, the higher the damaged starch content.



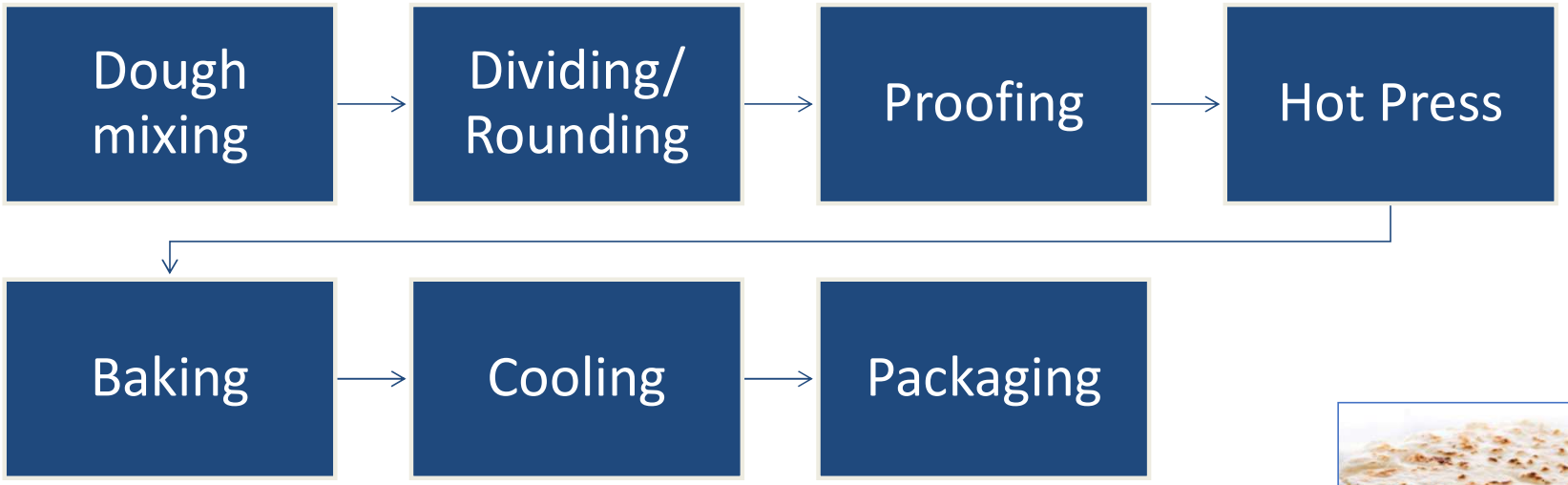
Materials and Methods: Tortilla Formula and Processing

Ingredients	% f.b.
Flour	100 (14%MC)
Distilled water	Abs.
Shortening	7
Sugar	0.5
Salt	1.5
Sodium bicarbonate	1
SAP	1.8
SSL	0.5
Potassium sorbate	0.4
Calcium propionate	0.5

Liu, Hou, Cardin, Marquart and Dubat, 2017



Tortilla Processing - Hot-Press Method



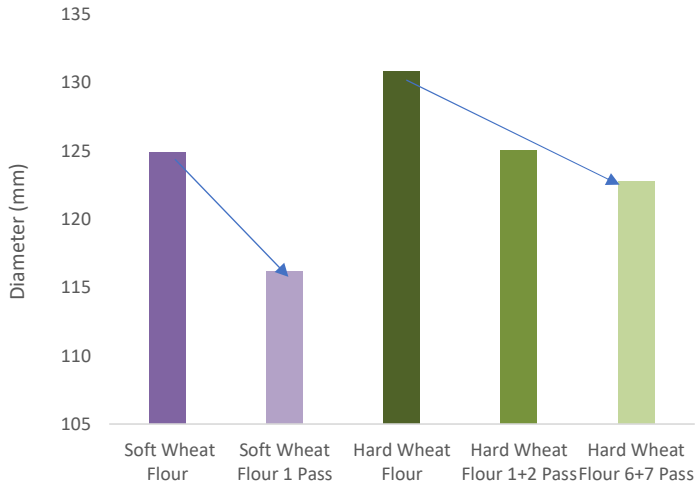
Materials and Methods: Tortilla Quality Evaluation

- Diameter
- Thickness
- Weight
- Color (Lab)
- Rollability
- Texture

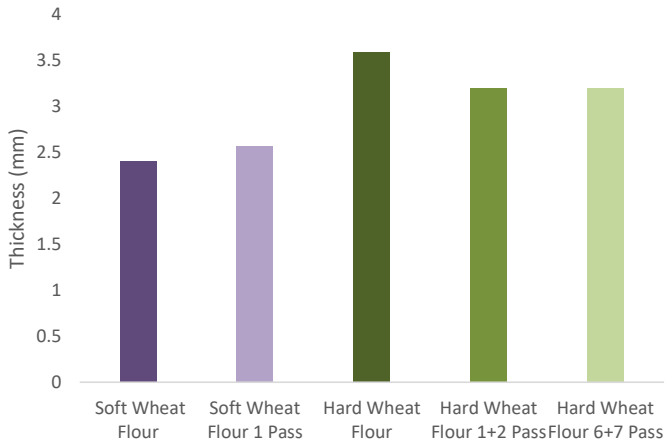
Results: Damaged Starch, Water Absorption

	Soft Wheat Flour		Hard Wheat Flour		
	As is	1 Pass	As is	1+2 Pass	6+7 Pass
Damaged Starch Content, % (AACC 76-33.01)	4.62 ±0.15 d	5.83 ±0.16 c	12.46 ±0.06 b	12.87 ±0.24 b	13.70 ±0.08 a
Water Absorption, %	53.5	54.9	62.6	63.7	62.1

Results: Tortilla Dimensions



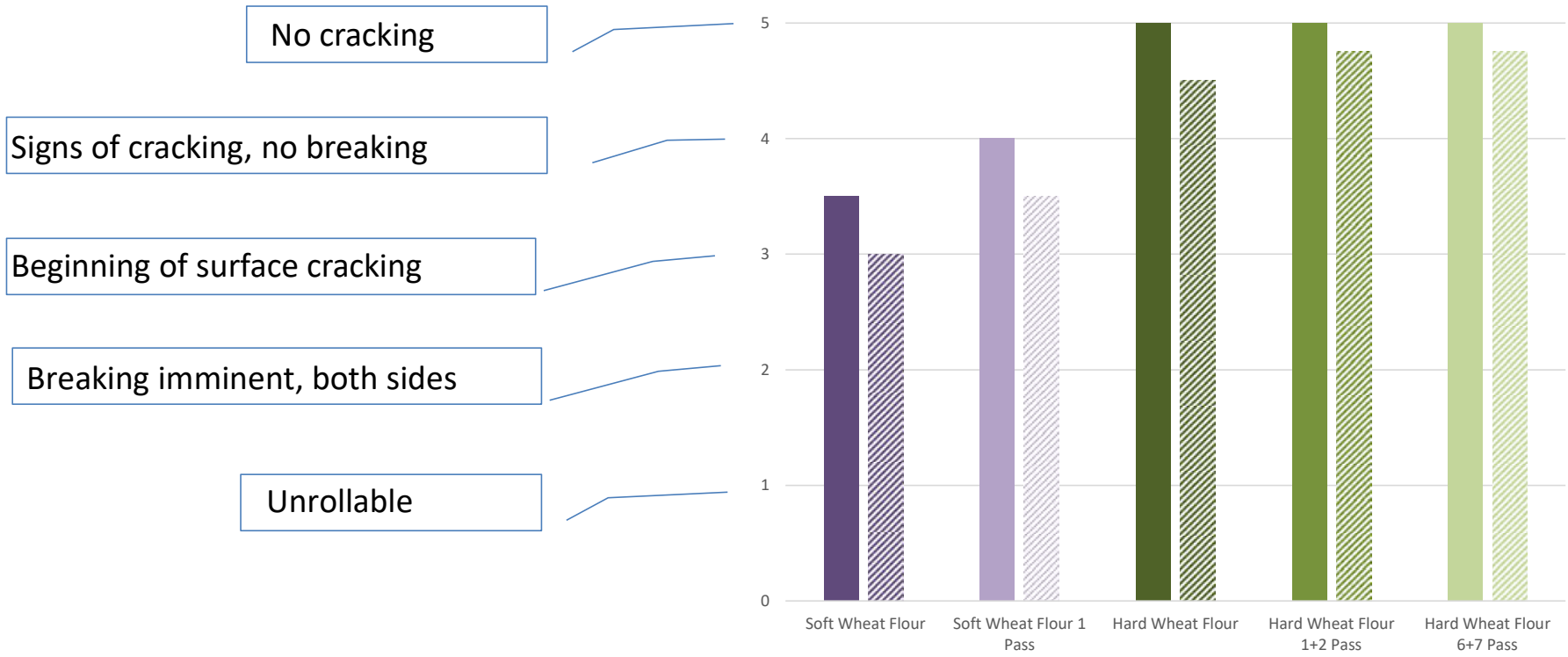
Diameter



Thickness

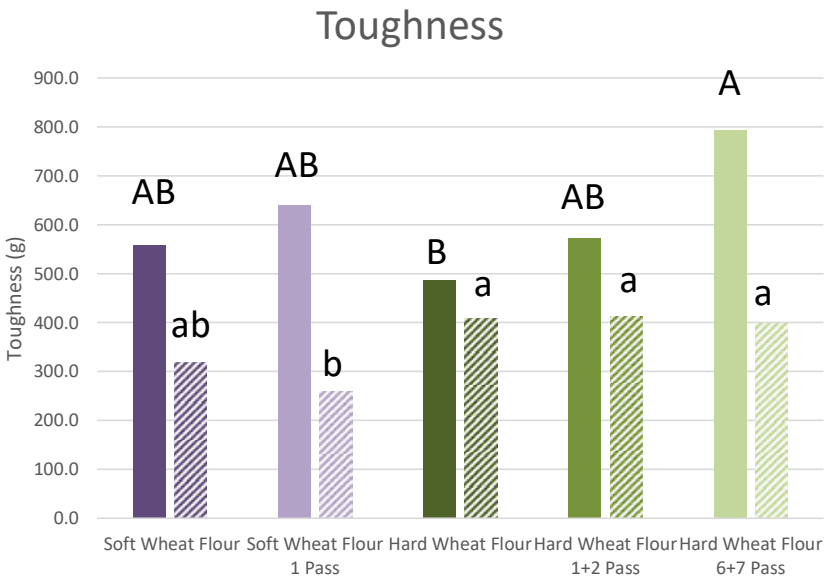
Weight

Results: Rollability Day 1 versus Day 7



- ✓ Effect of damaged starch on wheat flour tortilla quality

Results: Resistance/Toughness Day 1 versus Day 7



Hard wheat flour tortilla: Increased starch damage led to increased toughness at Day 1. This difference was completely lost after 7 days of storage.

Soft wheat flour tortilla: Damaged starch content caused no difference in toughness at both test days, but at 7th day.

Toughness is the maximum resistance to probe penetration and extensibility is measured from distance prior to burst.

Results: Extensibility Day 1 versus Day 7

At Day 1 there was no difference in extensibility between all the flours tested.
At Day 7, the tortillas produced with soft wheat flour and the hard wheat flour at 1+2 passes had the highest extensibility.

Toughness is the maximum resistance to probe penetration and extensibility is measured from distance prior to burst.

Discussion & Conclusion

Discussion & Conclusion

- Tortilla diameter is negatively correlated with flour strength and protein content.
- Tortillas made from flours with more damaged starch had a smaller diameter but longer shelf stability (Arora 2003).
- Wheat flours with a low damaged starch content are reported to produce tortillas with a lager diameter and a better texture than those with high damaged starch content (Wang et al., 2020).

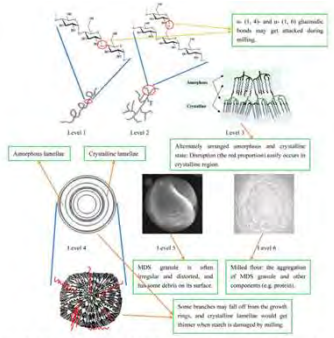


Fig. 1. Schematic diagram of MDS (milling damaged starch) hierarchical structure.

Discussion & Conclusion

- Both toughness and extensibility are related to starch retrogradation and starch-protein interactions.
- The lower damaged starch content and polyphenol oxidase activity in Eastern US soft winter wheat, ESW when compared with hard wheat flour would be advantageous because ESW wheat would require less water for dough preparation and would produce larger and brighter-colored tortillas (Ma and Baik, 2023).

Case study: Selecting the best wheat for a tortilla application

Lena Bosc-Bierne
Food, Products and Applications Manager

Project done in collaboration with the CYMMIT, Harinera Anahuac and Tortillera la Carreta

Materials

15 wheat varieties have been selected

#	Variety	SKCS Hardness Index	Flour Moisture Content	Flour Protein content
1	ALONDRA F2014	59,1	13,17	10,6
2	BACOREHUIS F2015	61,5	13,33	12,1
3	BORLAUG100 F2014	64,0	13,29	11,9
4	CIANO M2018	68,7	12,83	12,0
5	CISNE F2014	64,2	12,75	10,4
6	CONATRIGO F2015	63,0	12,79	11,7
7	FUERTEMAYO F2016	70,1	12,87	12,0
8	HANS F2019	66,5	12,9	11,7
9	KRONSTAD F2014	71,5	13,11	12,6
10	LUMINARIA	65,5	12,9	12,3
11	NORESTE F2018	66,2	13,14	12,6
12	NORMAN	58,3	12,71	11,8
13	TACUPETO F2001	62,6	12,84	11,5
14	VALLES F2015	76,3	12,63	12,5
15	VILLA JUAREZ	64,2	12,9	10,9
	Minimum	**58,3**	**12,6**	**10,4**
	Maximum	**76,3**	**13,3**	**12,6**
	Average	**65,4**	**12,9**	**11,8**

- *All hard wheat varieties, with strong or medium strong gluten*
- *Grown under optimal conditions at the CIMMYT research station in the North of Mexico*

Methods

Bühler experimental mill (70% extraction rate in average)

CIMMYT MR
International Maize and Wheat Improvement Center

SDmatic Standard test (ISO 17715)

KPM

Alveolab Standard test at constant hydration (ISO 27971)

CIMMYT MR
International Maize and Wheat Improvement Center

Mixolab Chopin+ test (ISO 17718)

HARINERA ANÁHUAC

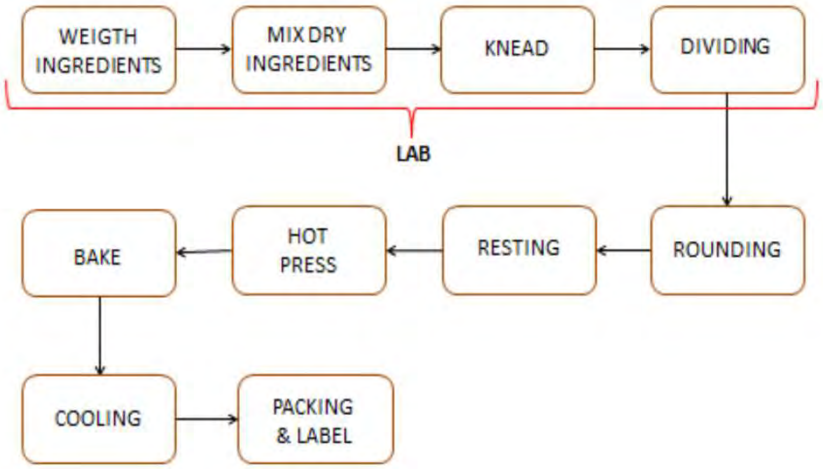
Tortilla Production Test protocol (internal method – see next slide)

LA CARRETA

Tortilla Production Test Protocol (details)

- **A SIMPLE FORMULATION AND A STRAIGHT FORWARD TEST PROTOCOL**

INGREDIENT	QUANTITY (g)
FLOUR	500
BAKING POWDER	20
SALT	10
SHORTENING	50
PRESERVATIVE	5
WATER	Varying based on WA-SRC



- **A COMPLETE TORTILLA ANALYSIS**


DIAMETER (cm)


THICKNESS (mm)


ROLLABILITY (score from 1 to 5)


FOLDABILITY (Score from 1 to 5)

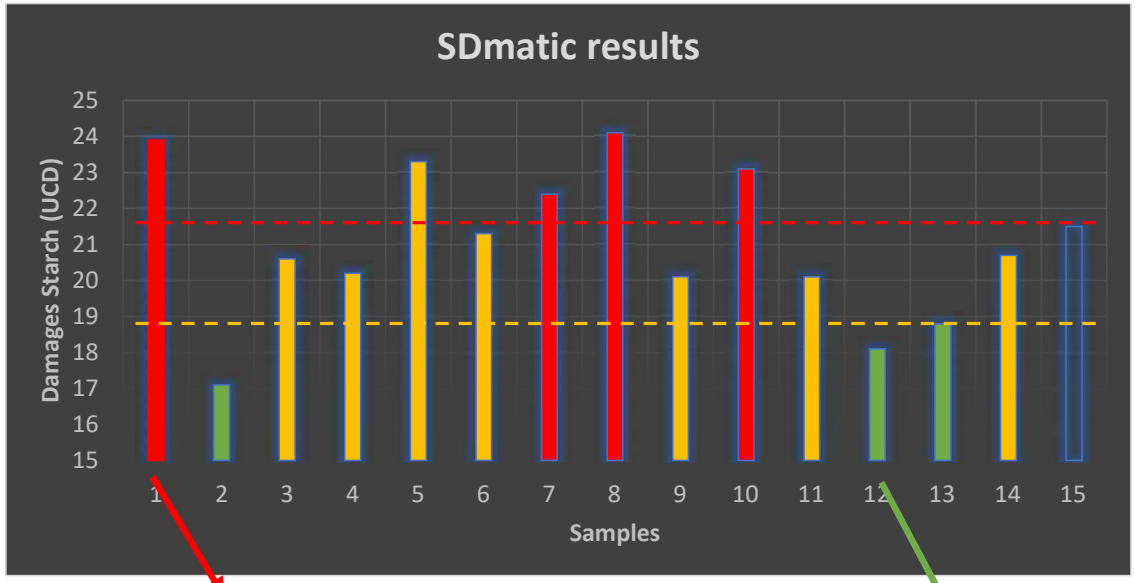

OPACITY (%)

TOTAL SCORE (From 0 to 7)

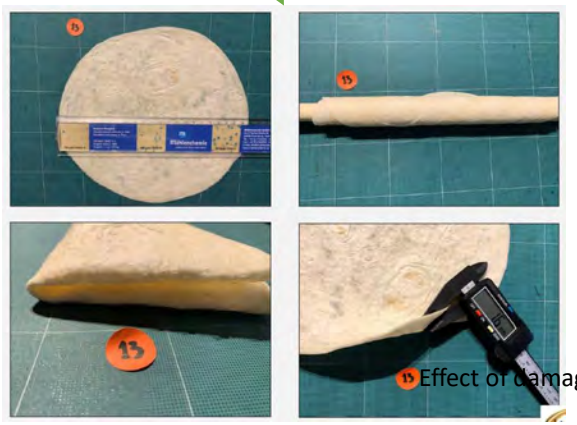
Overview of the Tortilla Results

Tortilla Quality Parameters								
#	WEIGHT (g)	DIAMETER (cm)	THICKNESS (mm)	OPACITY (%)	ROLLABILITY	FOLDABILITY	TOTAL SCORE	CONCLUSION
1	45,4	21,7	1,4	95	5	1	2	BAD
2	43,7	23,9	1,5	85	5	4	7	GOOD
3	43,6	22,9	1,5	85	5	3	4	MEDIUM
4	42,1	25,2	1,6	50	5	3	5	MEDIUM
5	43,5	23,5	1,6	80	4	2	5	MEDIUM
6	43	23,6	1,5	80	4	4	6	MEDIUM
7	43,2	22,3	1,4	90	4	2	3	BAD
8	44	22,8	1,4	75	4	2	1	BAD
9	43,7	23,9	1,3	85	4	3	6	MEDIUM
10	43,9	22,4	1,5	85	3	3	2	BAD
11	45,8	22,6	1,7	80	4	2	4	MEDIUM
12	45,1	23,2	1,5	95	5	4	7	GOOD
13	45	22,9	1,6	95	4	5	6	GOOD
14	45,7	21,7	1,5	90	4	3	6	MEDIUM
15								
Min	**42,1**	**21,7**	**1,3**	**50**	**3**	**1**	**1**	
Max	**45,8**	**25,2**	**1,7**	**95**	**5**	**5**	**7**	

Damaged Starch, the Best Indicator for Overall Quality of Wheat for Tortilla Making



- **UCD values > 22** predictive of poor quality tortillas!
- **UCD values < 19** predictive of high quality tortillas!



The SDmatic allows the definition of simple specifications to select high quality wheat for making tortillas!

Study Conclusion

OVERALL QUALITY

DIAMETER

ROLLABILITY +
OVERALL QUALITY

"Starch damage is the most important trait influencing the overall tortilla quality and should always be analyzed when producing flour for tortilla making"
Vega and Ibba, TIA Europe 2021

CONCLUSION

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.

- Considering the results of the current available literature, in addition to flour protein quantity and quality, damage starch content should be included to tortilla flour quality specifications.

CONCLUSION

Increased protein content and dough strength significantly decreased tortilla diameter, but improved tortilla shelf life. Medium protein content and dough strength were ideal to produce good quality tortillas. Four wheat lines (among 131 wheat lines from 1995 to 2007 in SRPN) showed premium tortilla quality, which could be important parental lines in a tortilla wheat breeding program (Zhang et al., 2021).

Eastern US soft winter (ESW) wheat, with high protein content and strength, appears to be suitable for making tortillas. The lower damaged starch content and polyphenol oxidase activity in ESW wheat when compared with hard wheat flour would be advantageous because ESW wheat would require less water for dough preparation and would produce larger and brighter-colored tortillas (Ma and Baik, 2023).

CONCLUSION

The future of tortilla industry is bright because the plant breeding of high producing nutritionally enhanced both wheat and corn genotypes, novel ingredients, new processing technologies as well as enhanced production equipment and quality testing instruments!

KPM Analytics Introduction

Our Mission

We craft assurance.

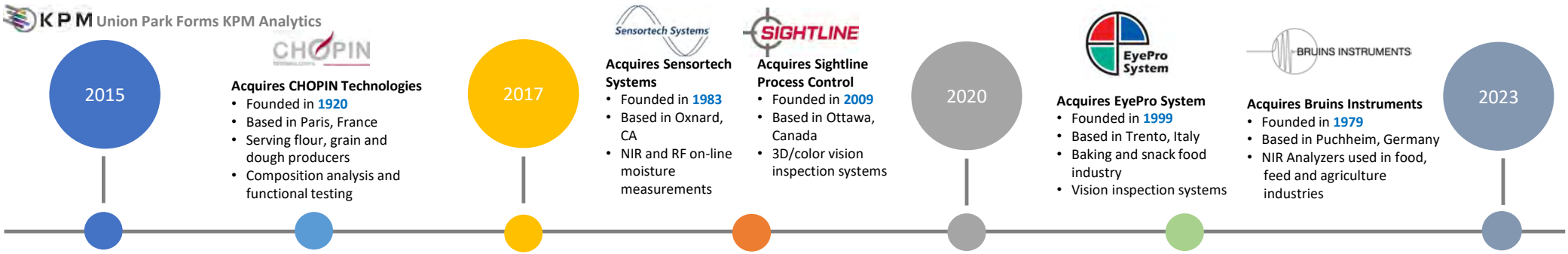
For our partners. For their customers.

KPM Analytics was formed in 2015 to bring together a portfolio of analytical instrument companies focused on the **food**, **agriculture**, and **environmental** sectors.

Currently, KPM Analytics consists of 9 companies and continues to expand its portfolio of industry experts and premium brands with back-to-back acquisitions.

Timeline and Progression of KPM Analytics

KPM Analytics brands have long and successful histories servicing customers worldwide



2015 — KPM Union Park Forms KPM Analytics

2016 — Acquires CHOPIN Technologies
- Founded in 1920
- Based in Paris, France
- Serving flour, grain and dough producers
- Composition analysis and functional testing

2017 — Acquires Unity Scientific
- Founded in 2001
- Based in Brookfield, CT
- NIR Analyzers used in food/feed/forage

2019 — Acquires Process Sensors
- Founded in 1996
- Based in Milford, MA
- On-line moisture gauges
- NIR technology

2020 — 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

2021 — ONE KPM
- New corporate leadership with CEO, CFO, CCO, VP Engineering and VP of Aftermarket
- Create and implement ONE KPM strategy to accelerate growth

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 food, feed and agriculture industries

2023 — SMARTVISIONWORKS

Acquires Smart Vision Works
- Founded in 2012
- Based in Orem, Utah USA
- Artificial Intelligence powered machine vision inspection

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

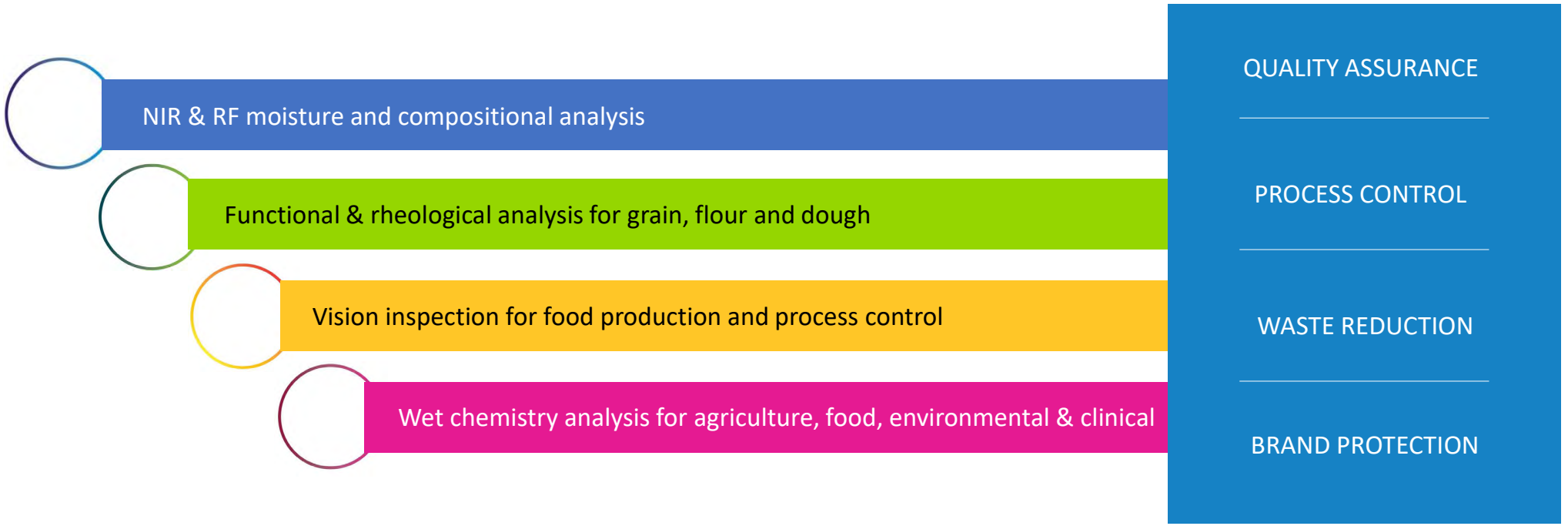
Germany (Frankfurt)
+49 (6721) 988 6720

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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