"Functional Starches and Flours in Savory Applications"

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Agenda

1. Native starch, chemistry and functionality
2. Functional starch & flour toolbox and troubleshooting
3. Enzyme effects
4. Functionality in dressings and sauces
   - viscosity, stability, texture, cost savings
5. Summary

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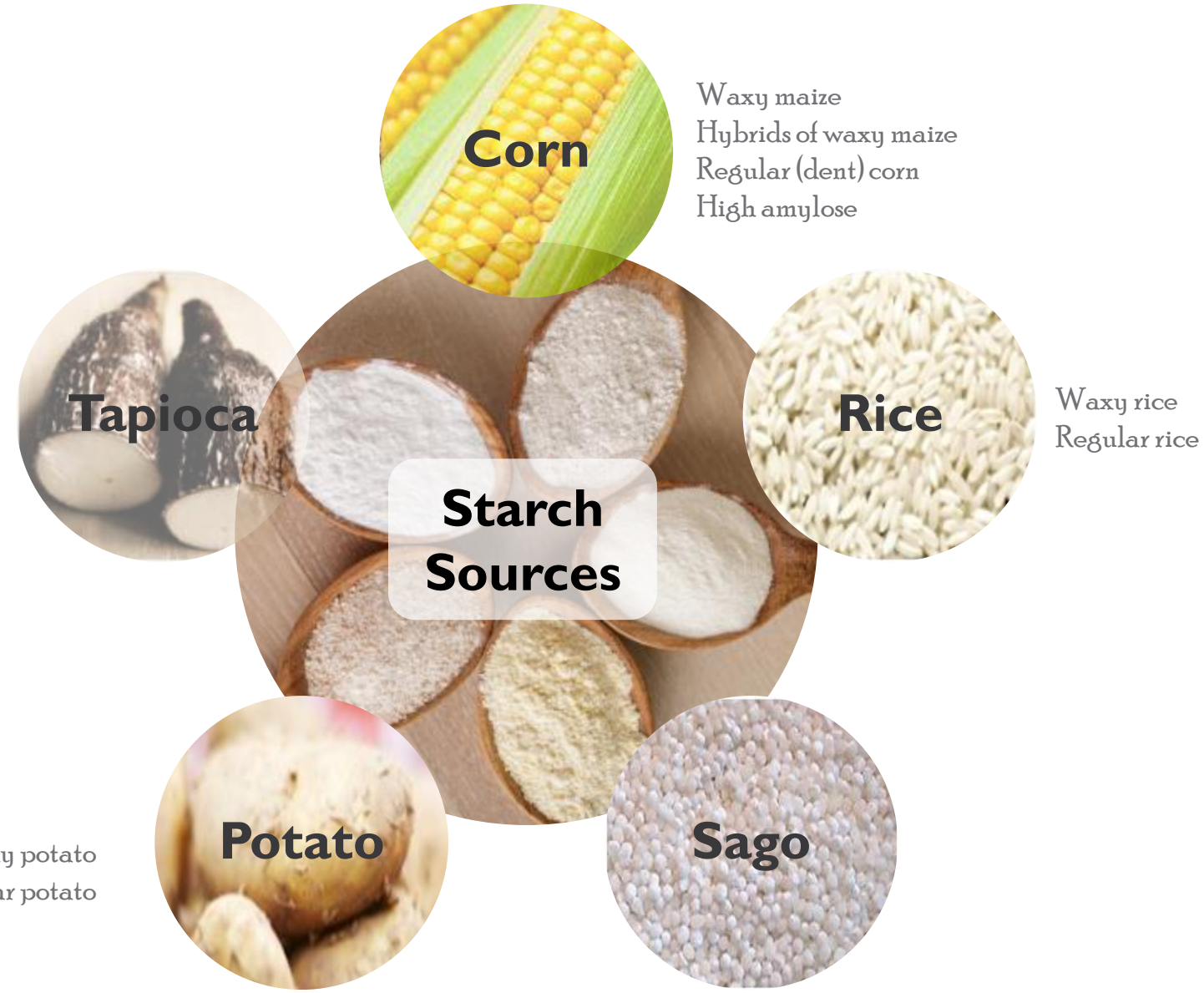
Starch and Flour Technology

Yeni Peña

WIDE RANGE OF NATURALLY SOURCED STARCH BASES



Other starch sources include wheat and pulses

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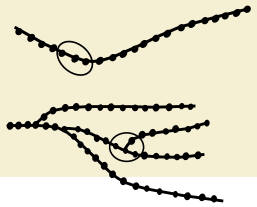
SUMMARY OF STARCH CHEMISTRY

Starch source: corn, tapioca, potato, rice, sago, wheat

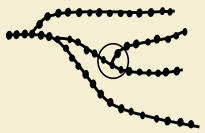
Total Carbohydrate
(Semi- crystalline granules, insoluble in water)

Starch Chemistry: Depending on the botanical source; the molecular weight, amylose and amylopectin ratios vary

Regular
> 17% Amylose
< 83% *Amylopectin*



Waxy
>99% Amylopectin



Molecular composition: Inherent molecular composition will impact final cooked texture & moisture retention

Amylose is a linear α-D-(1→4) glucosidic bond

Mw of amylose is less than 0.5M

Amylopectin is branched α-D-(1→4) & α - 1.6 glucosidic bond

Mw is > 50-100 M

Microscopy evaluations: Amylose-Iodine complex will have a bluish-purple color development

Texture: Amylose containing starches will gel and syneresis faster (E.g. Dent & Waxy corn)

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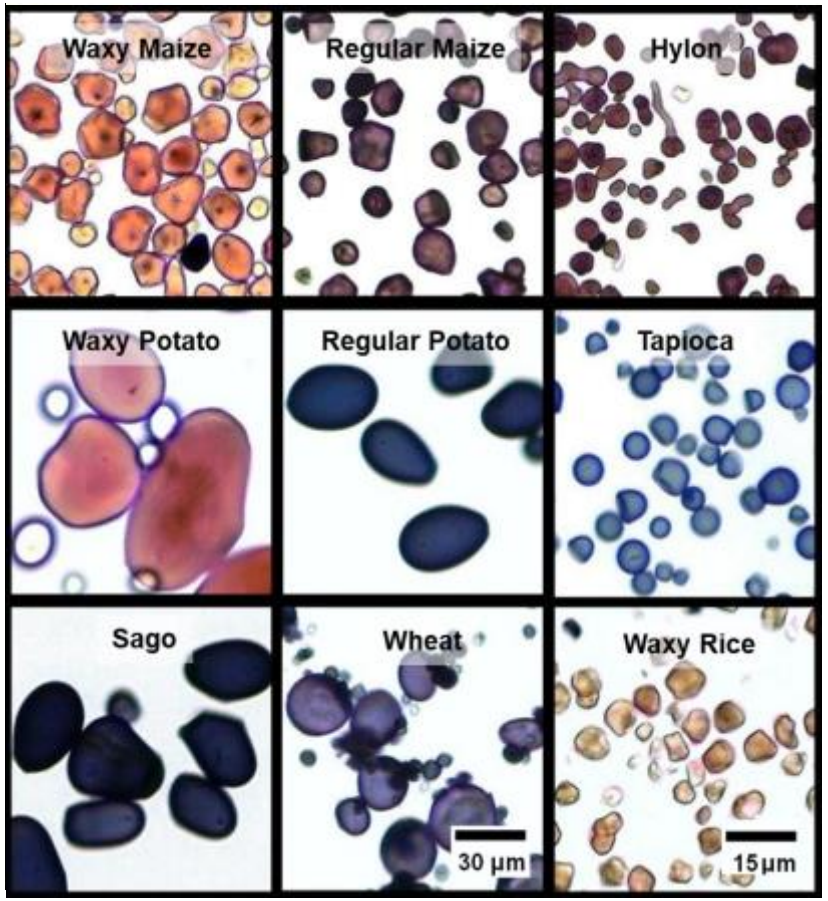
INHERENT PROPERTIES OF NATIVE STARCH

BRIGHTFIELD MICROSCOPY EVALUATIONS

- All uncooked starches are semi-crystalline & insoluble in water
  - Various source options= Different polymers =Different morphology = Different textures
- Each source can have unique flavor profiles



Stained with 0.1N Iodine

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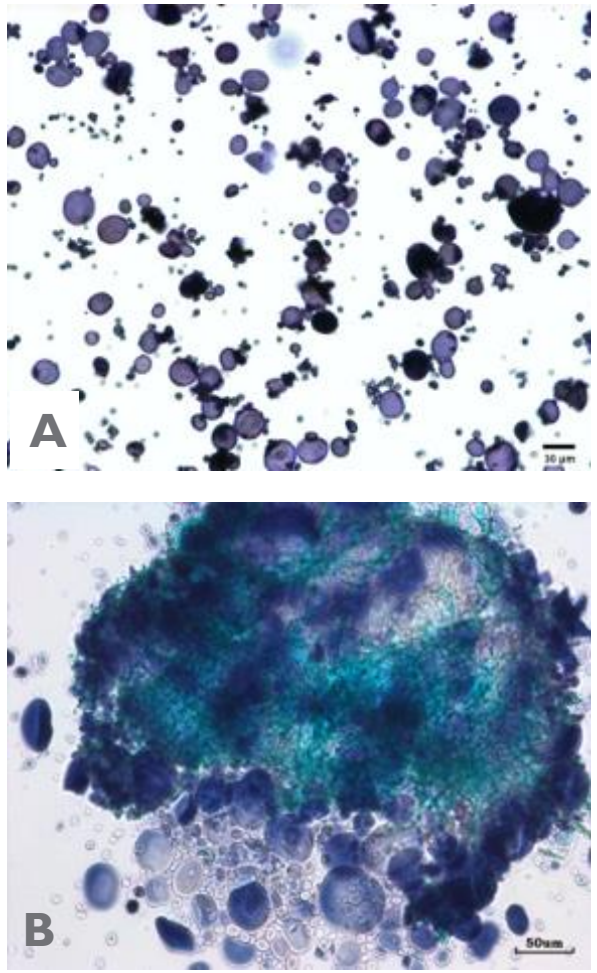
DIFFERENCES BETWEEN STARCHES & FLOURS

Starch variables can exist for a flour, the overall starch attributes for inherent properties are similar

Protein content is the defining factor in between a starch and a flour and can change properties significantly (except for Tapioca)

Flour types vary by protein content and it can contain other components such as fiber and micronutrients
Most flours are native



Brightfield microscopy with 0.1N Iodine Staining & fast green (a) wheat starch (b) wheat flour

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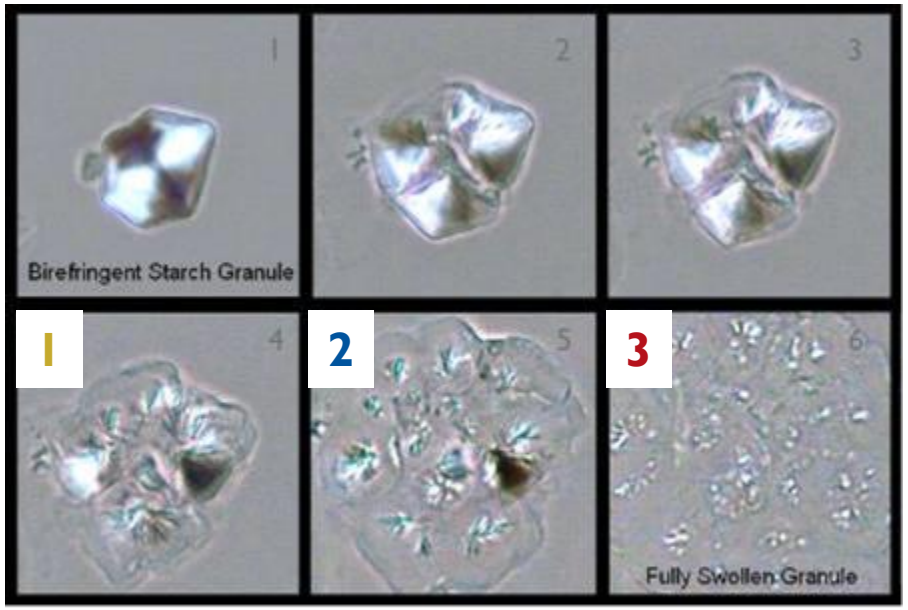
STARCH THICKENING AND SWELLING

Starch granules swell (gelatinization) in the presence of heat and moisture

Shear and the presence of salts/Ions affect starch swelling

As a result of starch granule swelling, irreversible changes occur, including:

1. Melting of the crystalline structure
2. Loss of birefringence
3. Leaching of soluble granular starch fractions & Increasing swollen granule size



Example of a waxy maize starch granule swelling under partially polarized light as it is being heated in water to 98°C. The diameter of this starch granule goes from 25 microns (Figure 1) to about 55 microns (Figure 6) when swollen.

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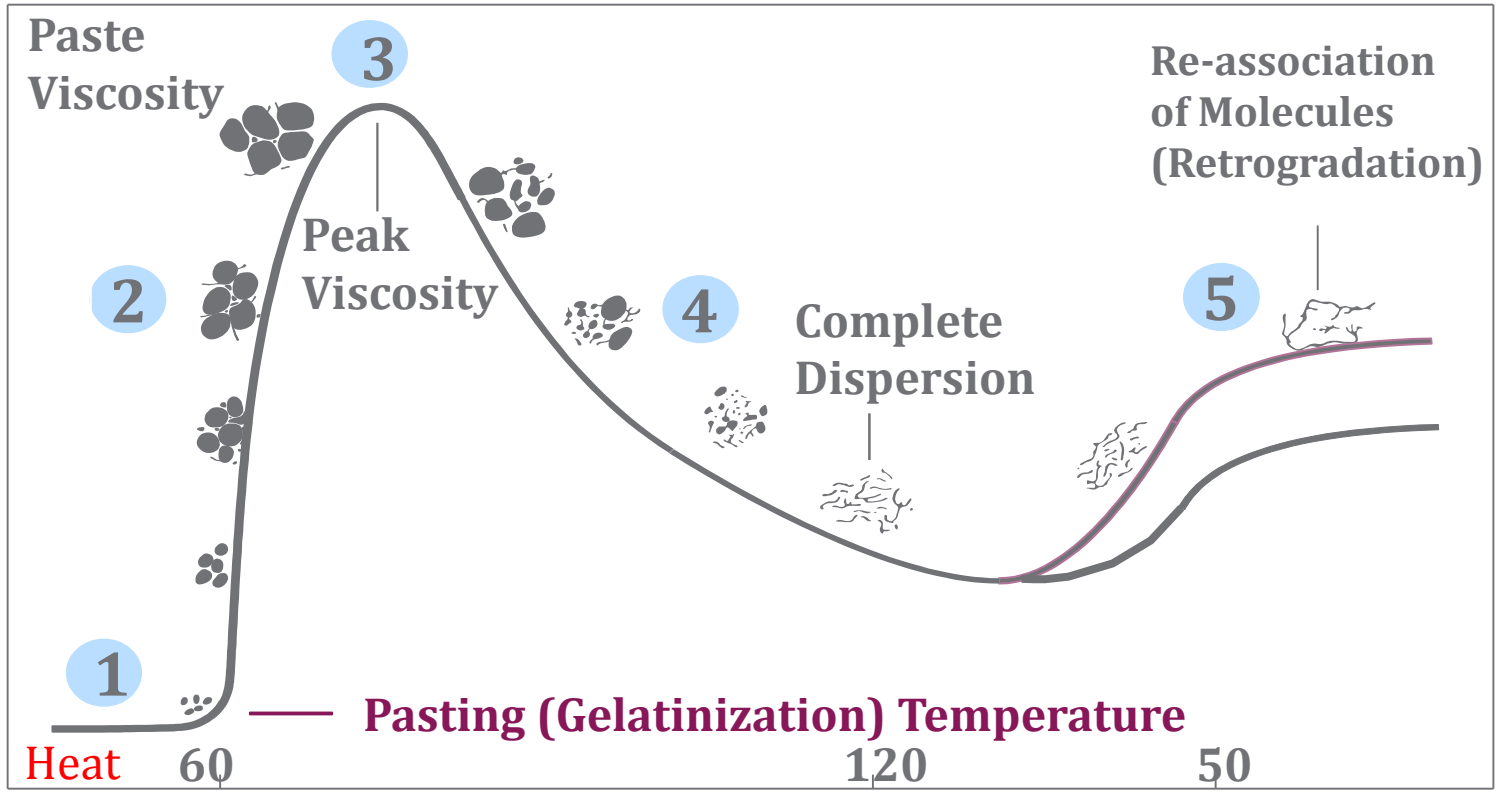
VISCOSITY CURVE – NATIVE (UNMODIFIED) STARCH

Gelatinization = Water Absorption = Viscosity Increase (1-4)

In native starches and flours retrogradation begins immediately after cooking (5)



"Bioactive carbohydrates in food". J.F.Kennedy and V.M.B. Cabalda. Chemistry in Britain, November, 1991. pp 1017-1020

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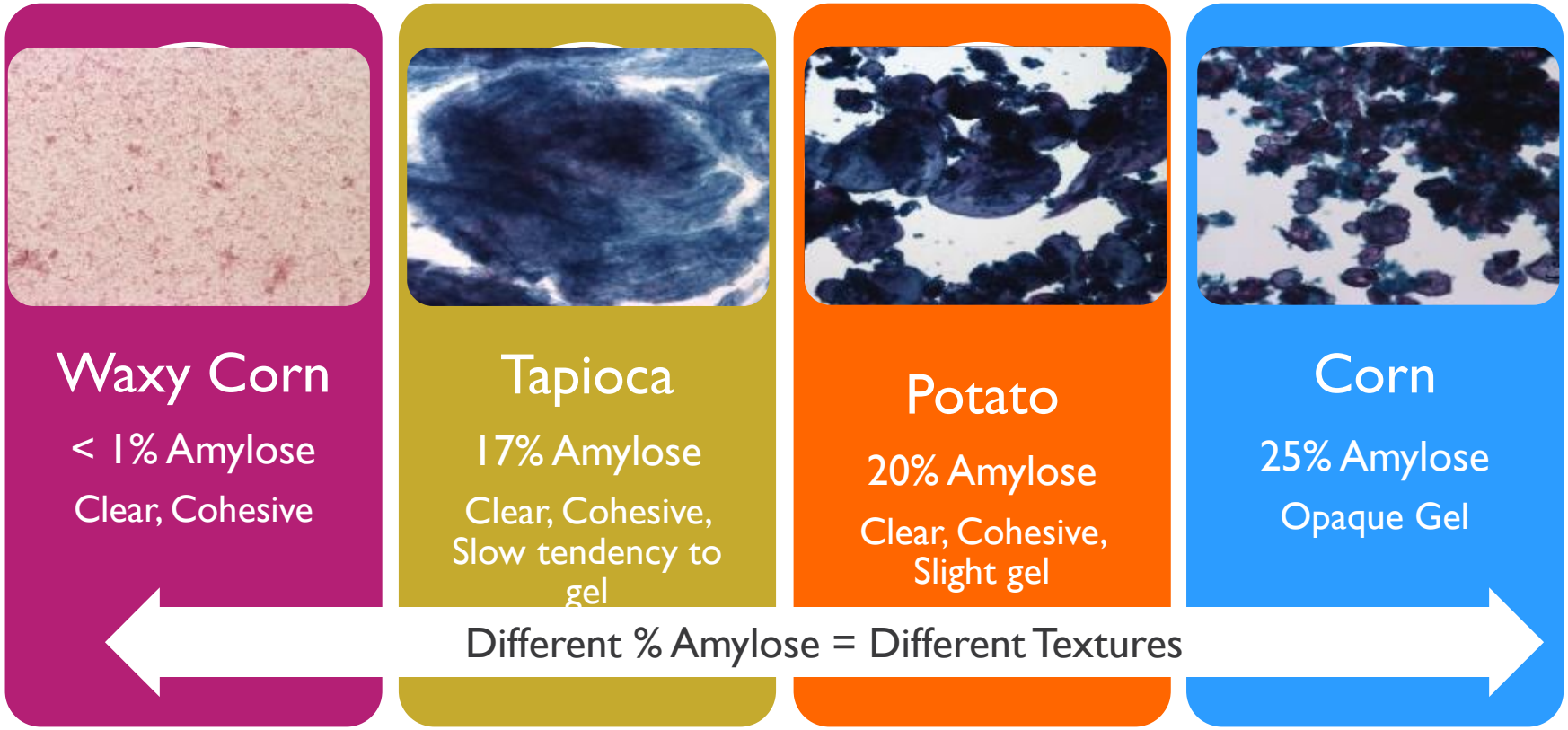
% AMYLOSE AND IMPACT ON TEXTURE

6% Starch cooked in water



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WHERE CAN I USE NATIVE STARCHES AND FLOURS ?

Native = No process tolerance = ↑Retrogradation =↑ Gelling, syneresis = ☹

Unhappy customer

Natives can provide slight viscosity improvement for immediate consumption or for other low moisture applications

Natives inherent properties:

→ Narrow peak viscosity range
→ Undesirable texture
→ Poor quality final product
→ Short shelf-life stability
→ No freeze/thaw stability

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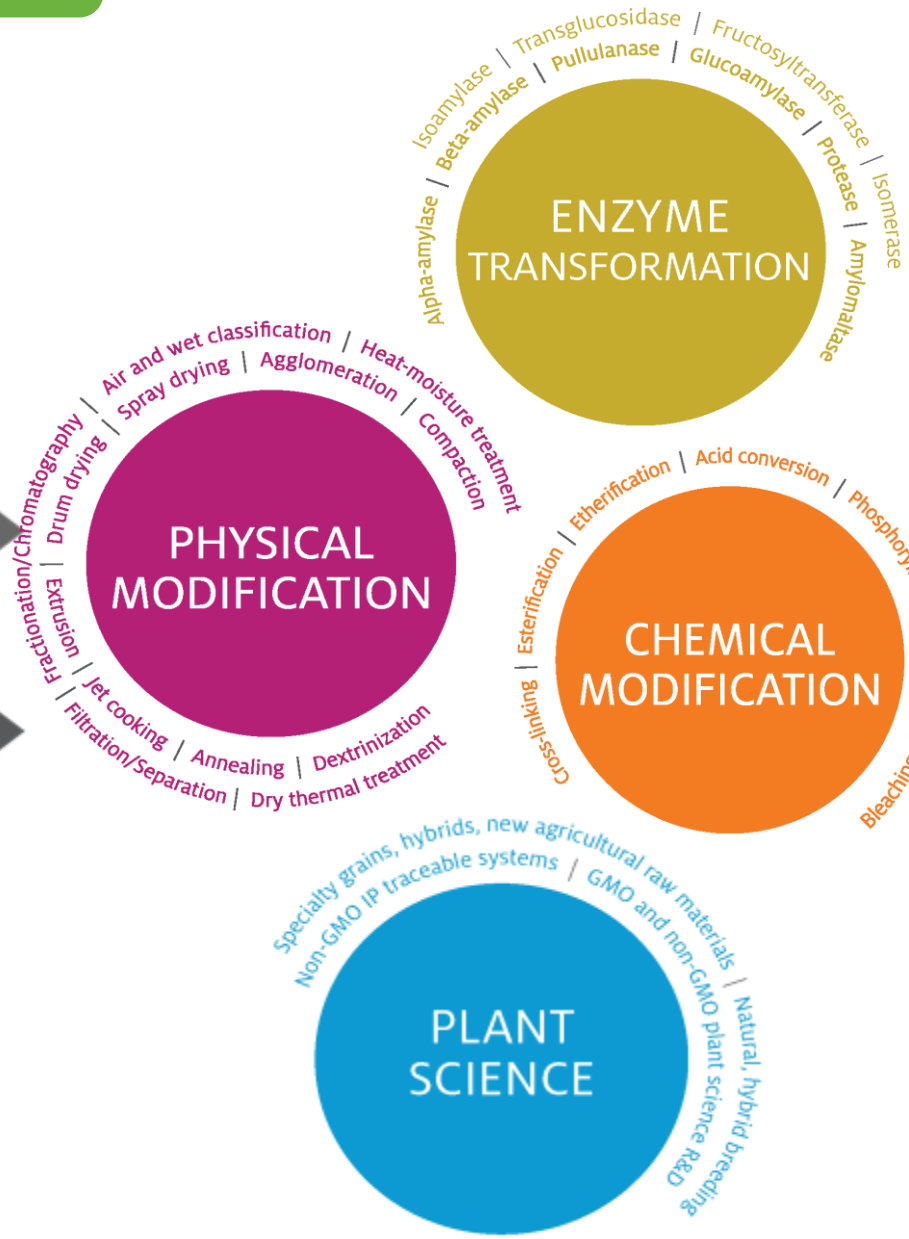
STARCH TECHNOLOGY TOOLBOX



OVER 1000 FUNCTIONAL INGREDIENTS

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OVERCOMING NATIVE STARCH INHERENT DEFICITS

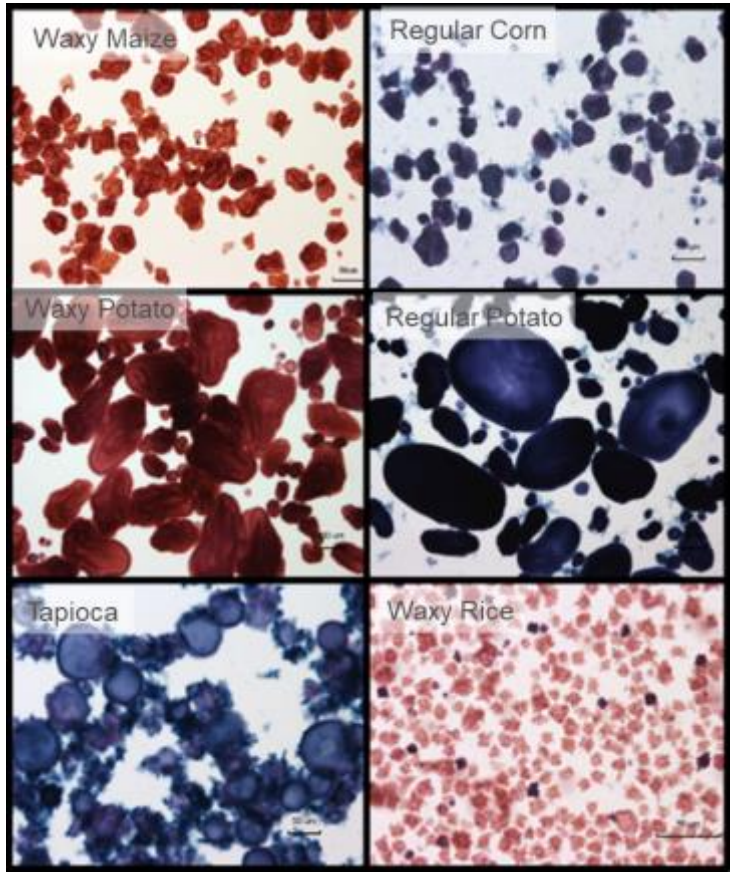
Chemical and or physical modifications will improve:

→ Process tolerance and retain viscosity

→ Shelf life stability

→ Freeze/thaw and refrigerated stability

Swollen starch granules are microscopically observed and the degree of starch cook can be determined



Brightfield microscopy with 0.1N Iodine Staining

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"COOK UP VS. INSTANT STARCHES"

"Cook up" or **"granular"** need cooking or heating to swell and provide viscosity

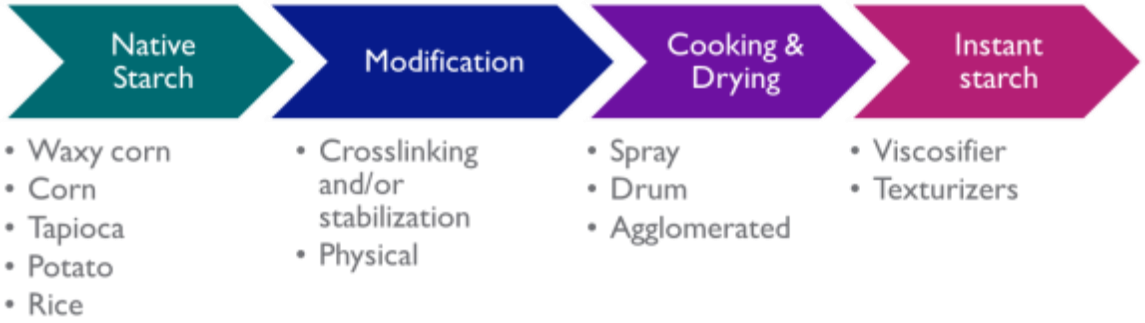
- Generally you need to reach at least 185°F and hold for 5-10 minutes
- Specific starch type and modifications can be further identified for varying process tolerances

Traditional modified starch
Industry standard

Functional native starch
Industry direction

"Cold Water Swelling (CWS)" or **"Instant"** starches do not need heating or cooking

- Spray dry or drum drying allows for an instant starch with all the chemistries/modifications (cross-linking, stabilization, etc.) associated with cook-up starches



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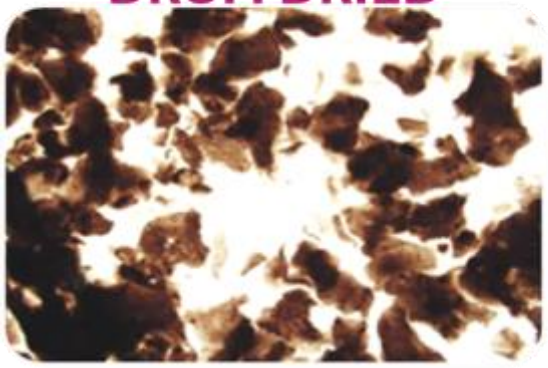
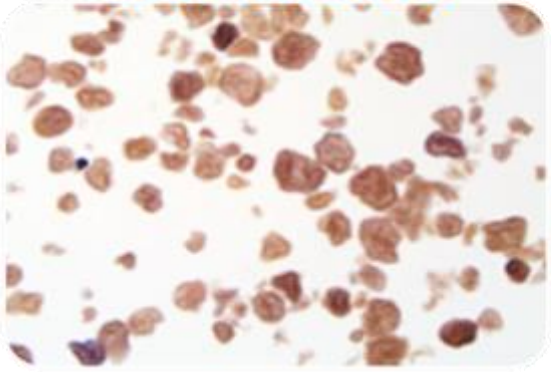
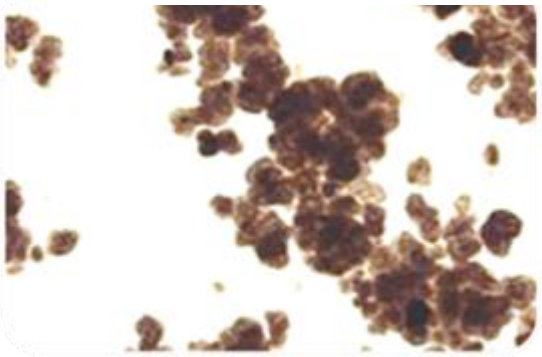
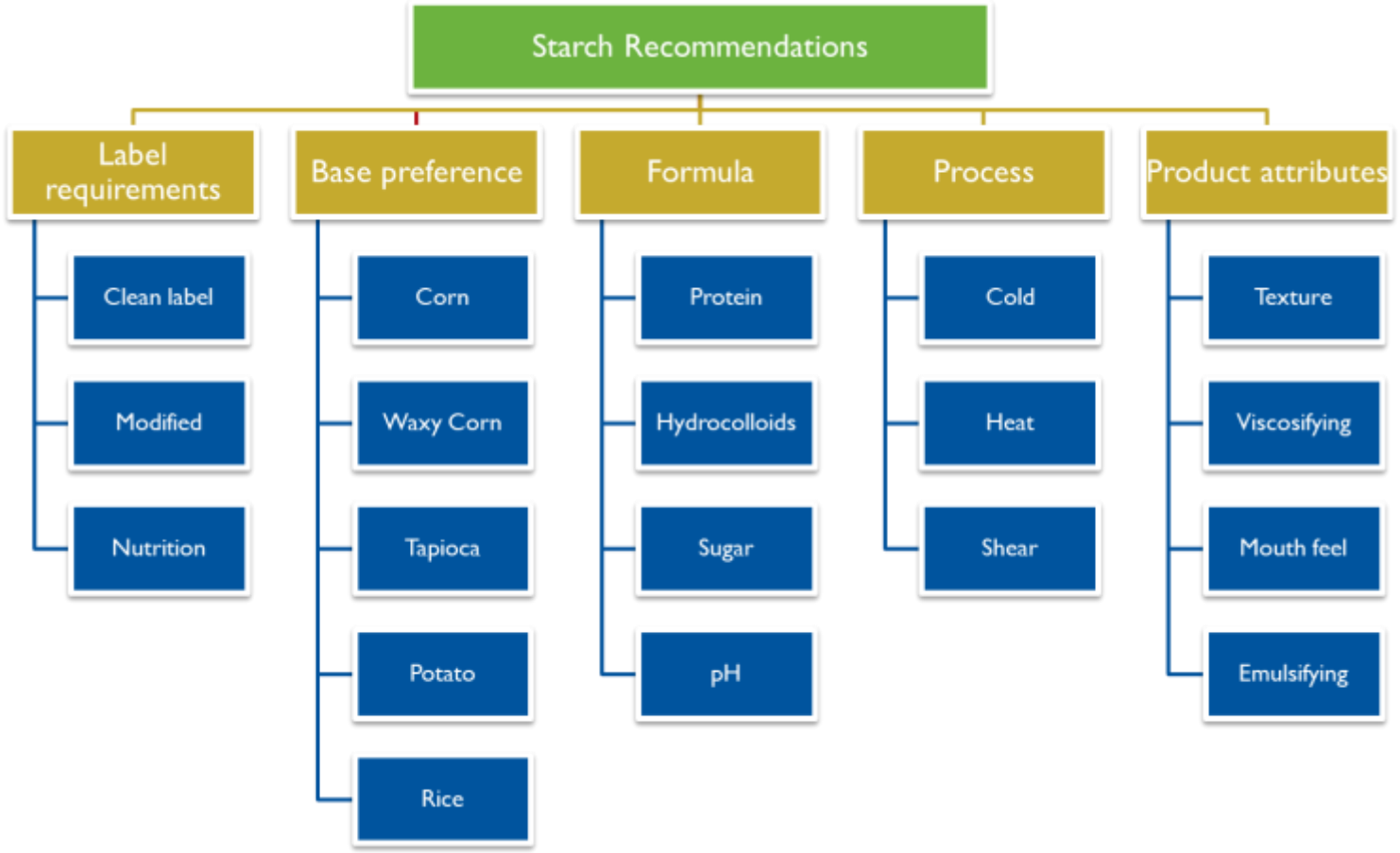
	DRUM DRIED	SPRAY DRIED	SPRAY DRIED & AGGLOMERATED
			
Starch integrity	Fragmented (Fine→Coarse)	Intact & Swollen (Fine)	Intact, swollen & aggl. (Coarse, decreased dusting)
Dispersion	Low	Moderate	Superior
Hydration & Viscosity development	Particle size driven (Coarse = slow)	Moderate & Steady	Superior & Steady
Shear tolerance	Low	Low → high	Low →high
Order of addition	Must mix with other dries	Mix with other dries	Can be added directly to water
Vortex & Mixing	Yes	Yes	Yes
Texture	Grainy – pulpy	Smooth	Smooth

How do I Choose

?



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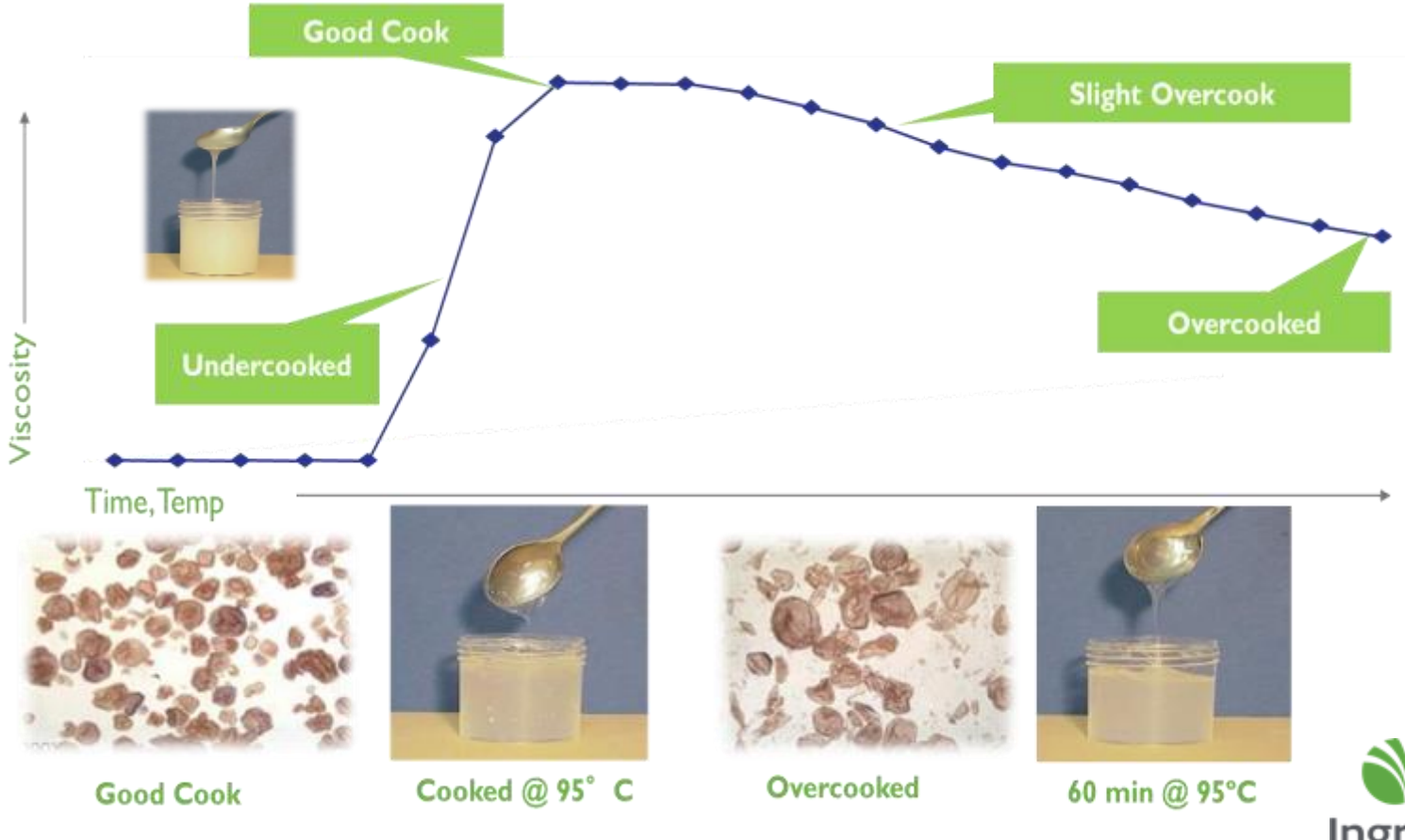
How do I know It's "working"

To build viscosity, evaluate the desired texture and degree of starch swelling
Typical usage levels for a sauce or a dressing can range between 1- 4%

Uncooked



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WHAT HAPPENS TO STARCH UNDER HIGH PROCESS SHEAR

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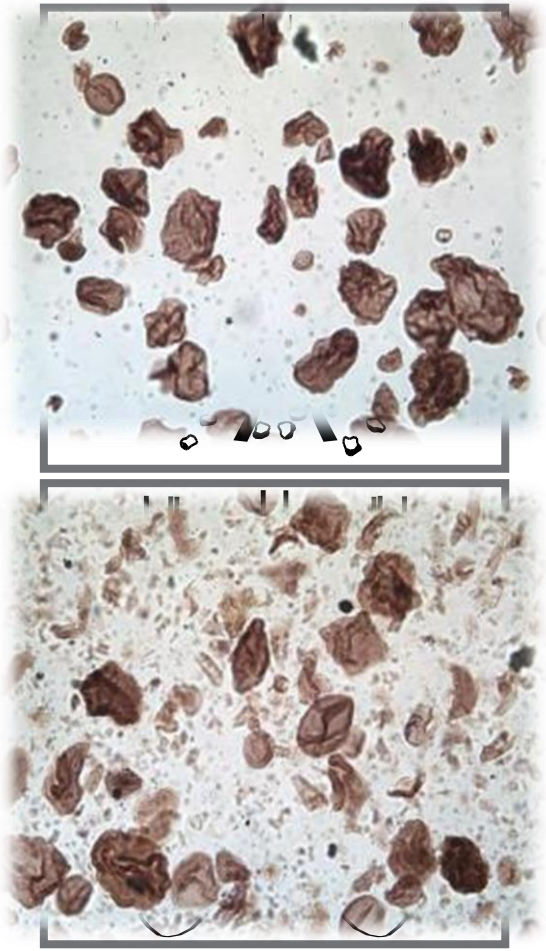

Shear provides additional energy into the food system to:

- Swell granules further
- Provide viscosity

Further shear can damage granules causing:

- Viscosity loss
- Cohesiveness
- Poor stability

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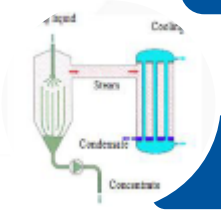
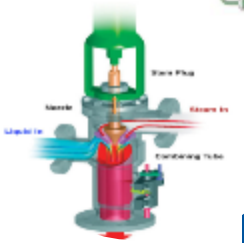
WHAT IS PROCESS SHEAR

?

Colloid mill, pumps, homogenizers



Flash cooling



Direct steam injection

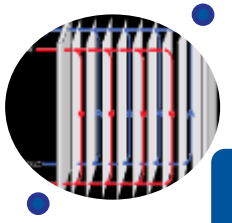
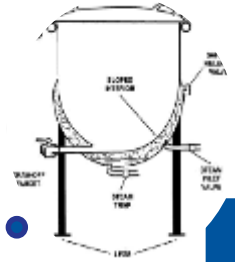


Plate heat exchanger



Steam jacket kettle

Stove top

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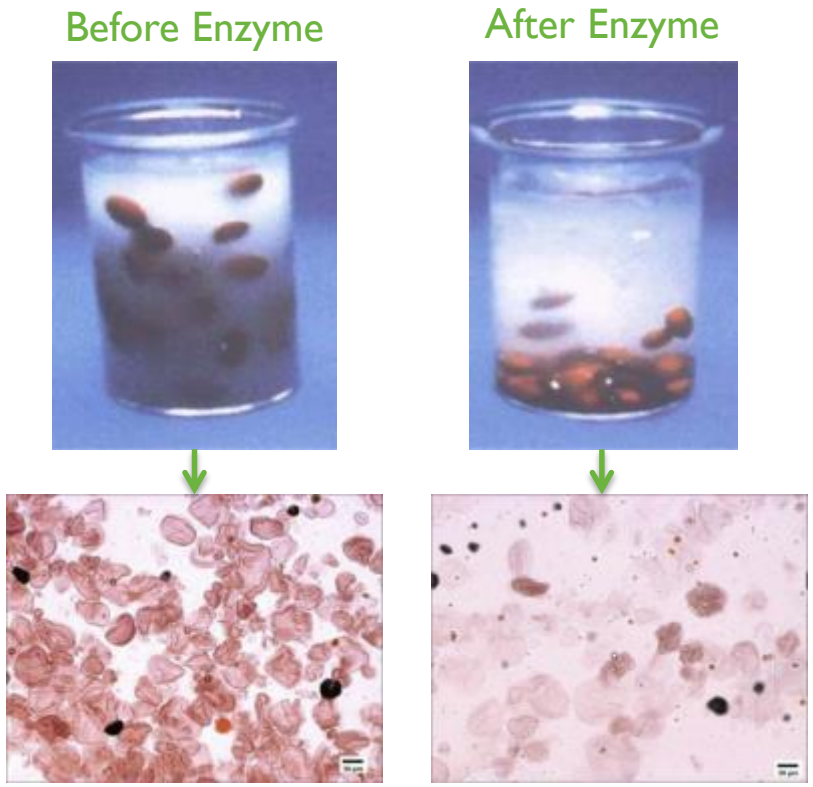
ENZYMES BREAK DOWN STARCHES AND FLOURS

- Enzyme presence = good/thick viscosity at production and eventually very thin in package or on shelf
- Enzymes are present in all living things [e.g. Spices, fruit, meats, nuts, eggs]
- Enzymes break down starch bonds [e.g. alpha- amylase rapidly breaks down starch, beta amylase, gluco-amylase & pullulanase]
- Rate of hydrolysis depends on amount present and time
- Enzymes can be deactivated with heat, adding vegetables and heating to at least 70°C, some suppliers provide enzyme deactivated spices etc..
- Starch is not resistant to enzymes



Quick enzyme test: Dose a starch solution with excess amounts of suspected ingredients and evaluate viscosity before and after. Complete confirmation with microscopy.

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INGREDIENT EFFECTS ON STARCHES AND FLOURS

Ingredient	Formula Effect	Starch & Flour effect	Solution
Acid	Lower pH	Faster cooking Possible overcooking	Higher process tolerant starch or change the order of addition
High Oil & Fat	Oil coats starch	Delays gelatinization/swelling (may be beneficial for instant starches)	Hydrate starch/flour prior to oil/fat
High sugar	Hydration competition	Undercooking	Use Instant or lower process tolerant starch Hydrate starch/flour first Increase temperature
High Protein	Hydration competition and viscosity increase	Possible under cooking	Decrease starch usage levels, dry mix protein and starch, or hydrate starch/flour first

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WHAT FUNCTIONALITY STARCH PROVIDES FOR DRESSINGS & SAUCES

?

Viscosity

- **Starch selection**: Clean label, lifestyle claims, Modified
- **Process tolerance:** formula specifics such as pH, temperatures, mixing, homogenizing
- **Instant vs. cook up**
- **Ingredient suspension**

Stability

- **Emulsify**
- **Shelf stability**
- **Room temp.**
- **Cold temp.**
- **Freeze/thaw cycles**

Texture

- **Indulgence**
- **Texture**
- **Creamy**
- **Pulpy**
- **Set**
- **Opacity**

Cost Savings

- **Converting to instant process**
- **Replacing costly ingredients with a co-texturizer**
- **Cost in Use**

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Starch Selection for Viscosity & Stability

Bicheng Wu

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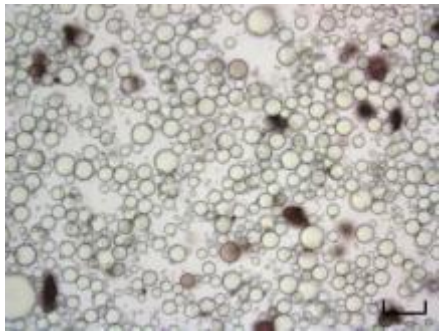
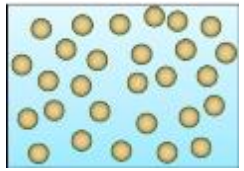
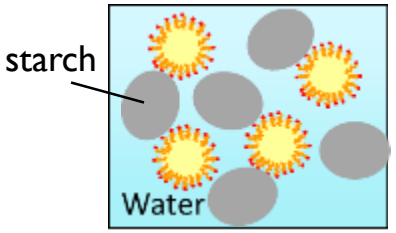
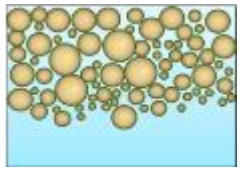
FUNDAMENTAL VIEW OF DRESSINGS AND SAUCES



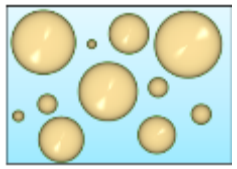


Kinetically Stable Emulsion

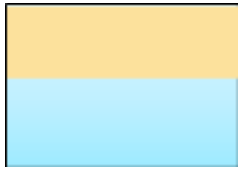




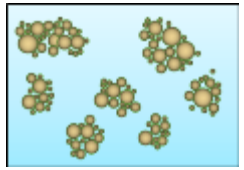
Gravitational Separation (Creaming & Sedimentation)



Coalescence or Ostwald Ripening



Phase Separation



Flocculation

- Starch
- Oil droplets
- Hydrocolloids
- Proteins
- Emulsifiers
- Fibers
- Other visible particulates

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Types of Salad Dressing

- General types
  - Pourable
  - Spoonable
  - Dry Mix
- Regular fat, reduced fat, or fat free
- Creamy or vinaigrette
- Cold preparation or cook-up
- With or without eggs
- Organic or "Natural"
- Standards of Identify (FDA Code of Federal Regulations (CFR))
  - Mayonnaise,
  - Spoonable salad dressing,
  - French dressing

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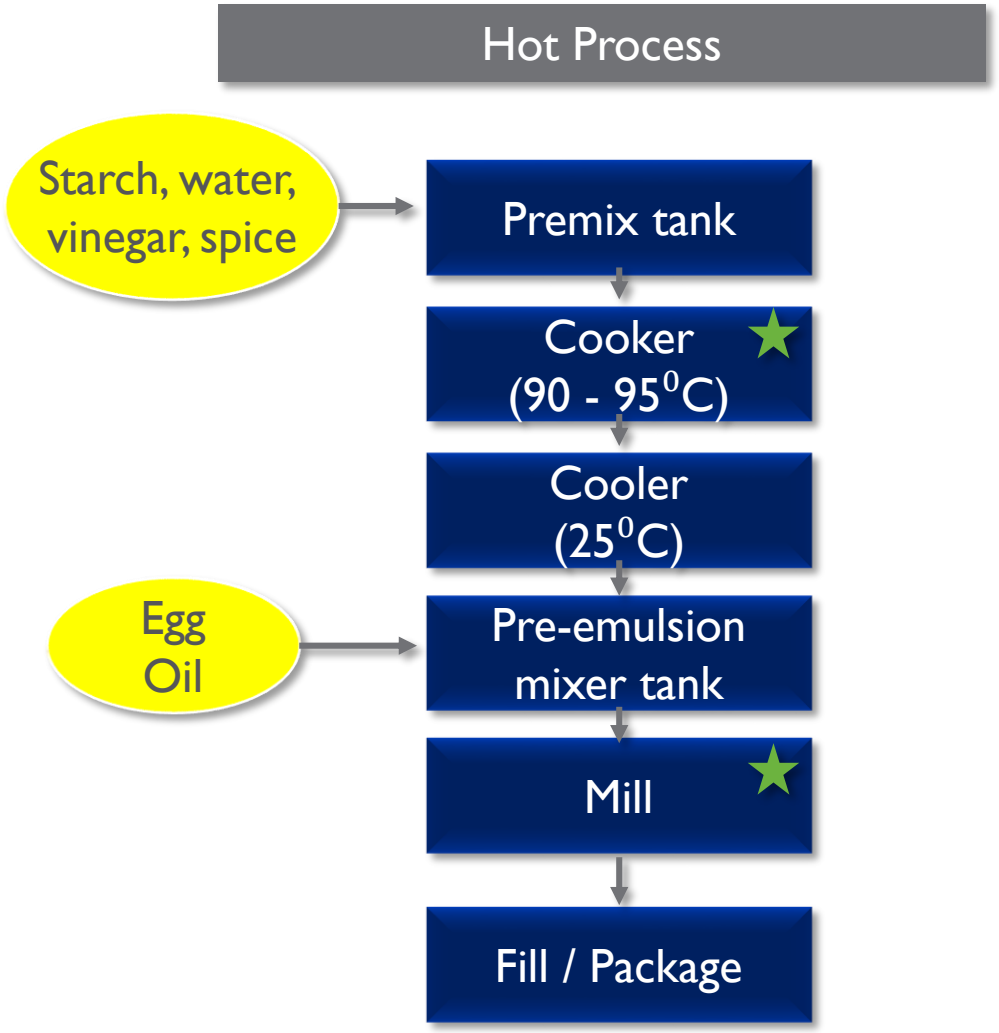
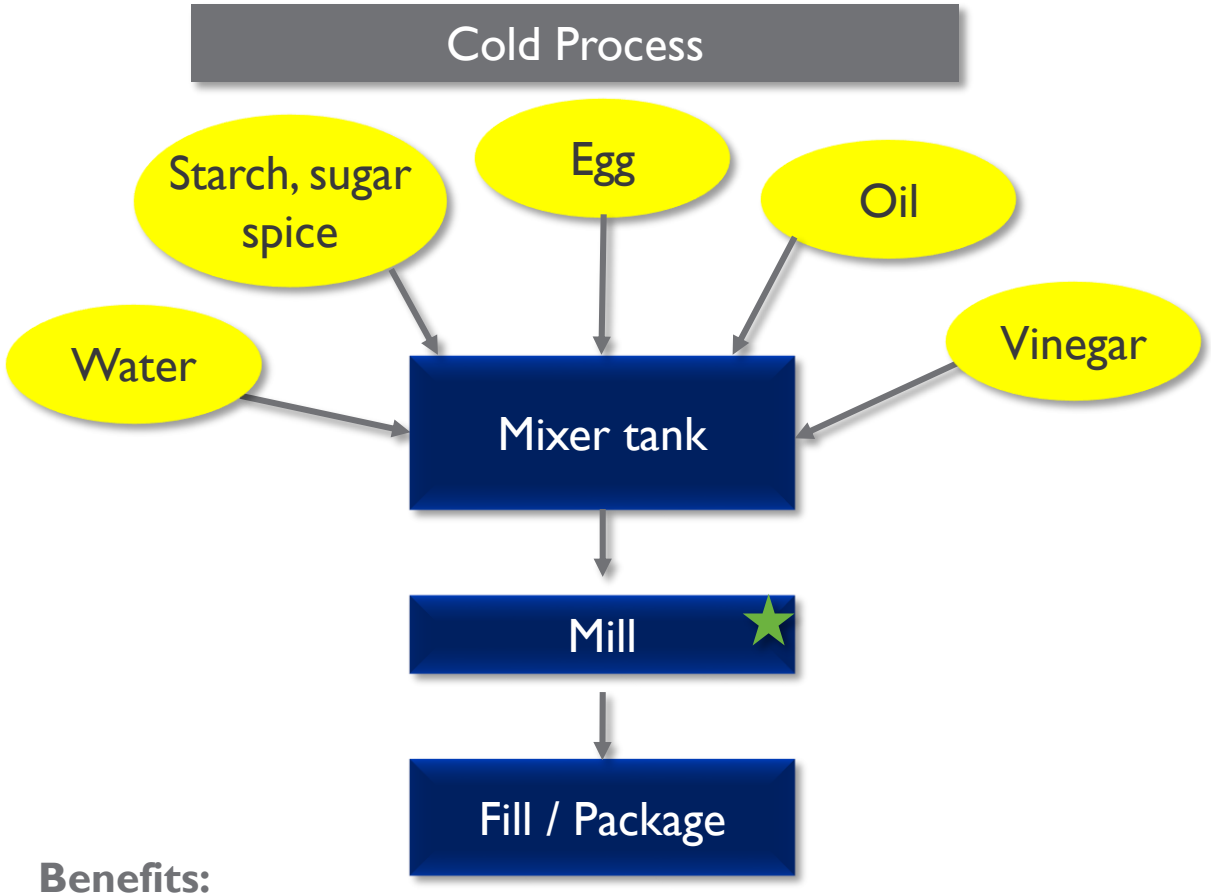
Typical Dressing Process





Benefits:

- Ease of processing, energy savings, cost saving
  - No cooking, no cooling
  - Simply blend starch with dry
  - ↓ product loss
  - Easy control of starch cook, hence quality

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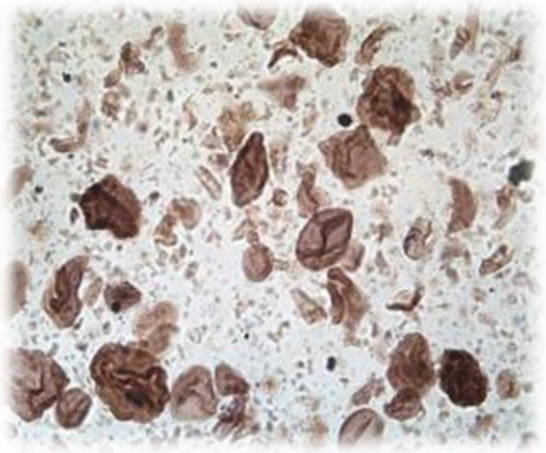
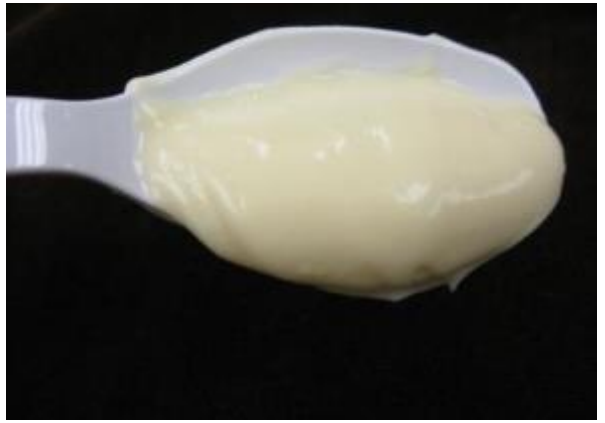
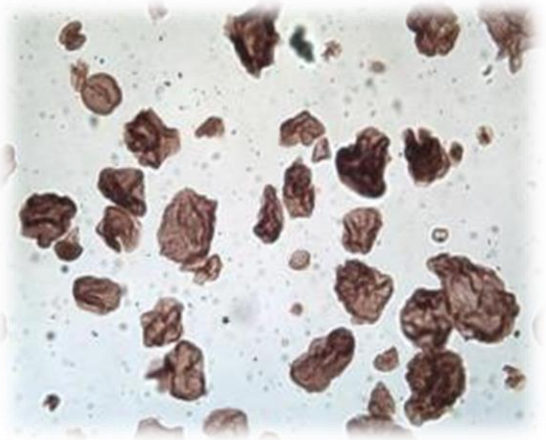
THE NEED FOR SHEAR TOLERANCE







Fragmented starch granules cause:

- Viscosity Loss
- Long texture / cohesive
- Loss of emulsion stability
- Decreased shelf life stability

Intact starch granules maintain:

- Viscosity
- Optimal texture
- Emulsion stability
- Shelf life stability

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STARCH RECOMMENDATIONS & PROCESSING TIPS

- **High process** tolerance required due to high shear and low pH
- Typical **usage levels** depend on oil content
  - 3-6% (spoonable dressings)
  - 2-5% (pourable dressings)
- **Do not overshear**
  - For textural stability
- **Cook optimally** for hot process
  - Maximum viscosity
  - Less cohesiveness
  - More cling: need more cooking or more passes through the mill
- **Spray dried starch** with process tolerance for cold process
  - **Agglomerated** version for better **dispersion**

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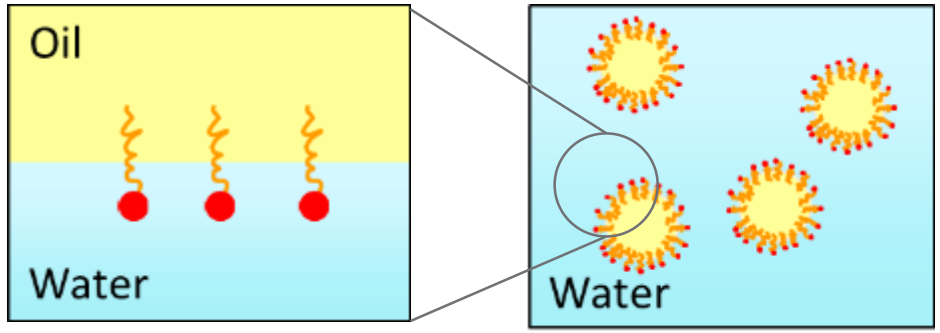
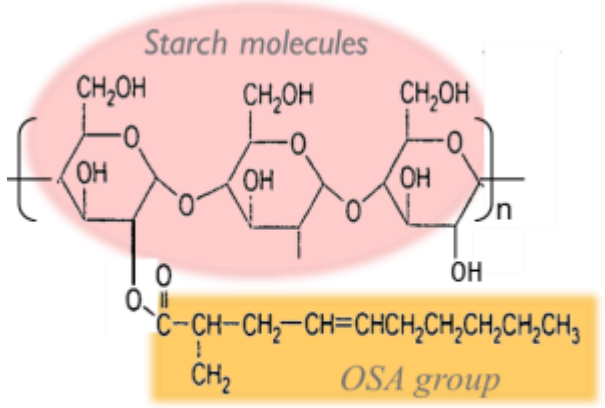
EMULSIFYING STARCHES



Hydrophobic Hydrophilic



OSA Starch

Emulsifier functions:

- ✓ Surface active
- ✓ Disperse oil to small droplets
- ✓ Stabilize oil droplets

→ Oil layer

→ Starch-water layer

Low fat mayo without emulsifier

- ✓Effective emulsifiers
- ✓ Not pH/salt sensitive
- ✓ Easy to use
- ✓ Heat stable
  - suitable for heat stable mayonnaise

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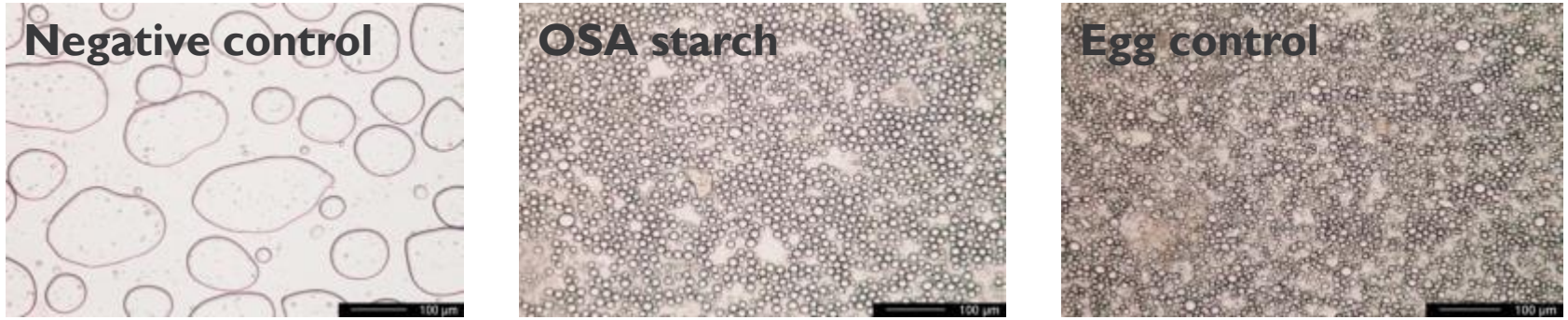
EMULSIFYING STARCHES

Making a cost-effective, process robust and shelf-life stable Emulsion



1% Emulsifying starch can replace 5% liquid egg-yolk or 2% egg yolk powder

Special claims: egg-free, cholesterol free, vegan

- reduced safety-risks (salmonella, dioxine, etc.)
- premium quality without egg
- batch-to-batch consistency guaranteed

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VISCOSIFIERS AND FREEZE THAW STABILITY IN SAUCES

- Functional starches and flours can provide different degrees of stability
- Various bases and process tolerance
- Freeze/Thaw stability is an indicator of refrigerator and subsequently room temp shelf stability
- In general "Waxy" bases provide more F/T stability etc..
- To improve overall freeze thaw stability starch and flour should be at above 1.5%

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READY MEAL – FREEZE-THAW STABILITY

Ingredient	%
Whole Milk	91.28
Unsalted Butter	5.00
White Pepper	0.02
Salt	0.30
Starch/Flour*	3.00
Soy Lecithin	0.40
Total	**100.00**

1. Functional native waxy corn 1 starch can surpass 1-2 F/T cycles
2. Functional native waxy corn 2 starch can surpass 3-5 F/T cycles
3. Functional native tapioca flour can surpass **8 F/T cycles** : no syneresis at all and graininess developing at the end of the cycling

Functional Native Tapioca Flour	Functional Native Waxy Corn Starch 1	Functional Native Waxy Corn Starch 2

✓ Appealing "flour" label with outstanding freeze-thaw stability

Ingredion

Co-Texturizers

TOMATO-BASED PRODUCTS
EXAMPLES OF KEY PROPERTIES NEEDED

- Pizza sauce
  - Bake stability
  - Water retention properties
  - No boil-out
- Pasta sauce
  - Grainy texture
  - Even coating
  - Cling on pasta
- BBQ sauce
  - Enhanced cling
  - Suspension
  - Moisture management

Ingredion

Starch Functional Properties

Thickener & Texturizer

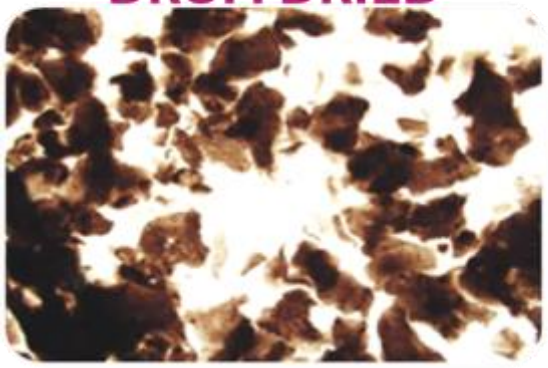
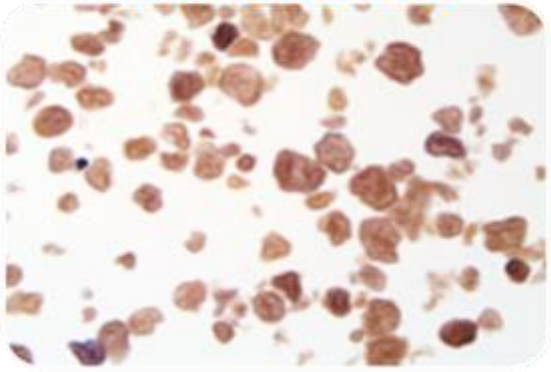
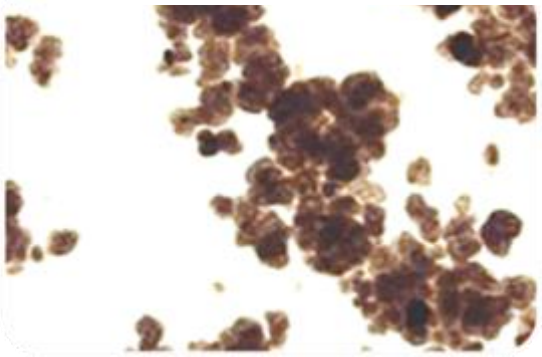
Tomato Solids Replacer

Mouthfeel Enhancer

Tomato Based Soups & Sauces

Ingredion

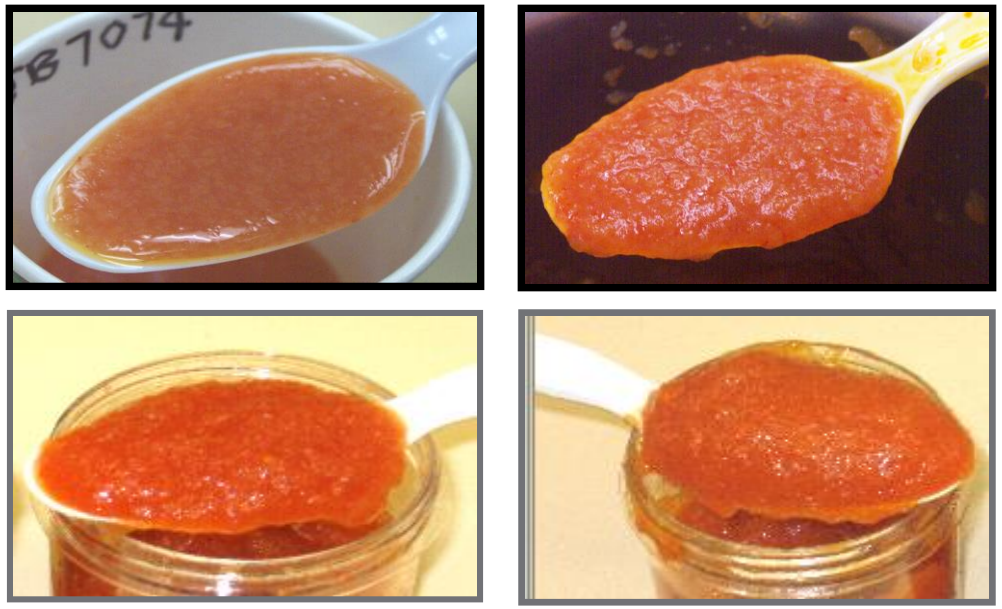
PULPING AGENTS

	DRUM DRIED	SPRAY DRIED	SPRAY DRIED & AGGLOMERATED
			
Starch integrity	Fragmented (Fine→Coarse)	Intact & Swollen (Fine)	Intact, swollen & aggl. (Coarse, decreased dusting)
Dispersion	Low	Moderate	Superior
Hydration & Viscosity development	Particle size driven (Coarse = slow)	Moderate & Steady	Superior & Steady
Shear tolerance	Low	Low → high	Low →high
Order of addition	Must mix with other dries	Mix with other dries	Can be added directly to water
Vortex & Mixing	Yes	Yes	Yes
Texture	Grainy – pulpy	Smooth	Smooth

TOMATO KETCHUP – VISCOSIFIER & SOLIDS REPLACER

- **PULPY/GRAINY** (usage level 0.5-4%)
  - Improves appearance, texture, and mouthfeel
  - Fruit/ tomato solids replacement

Before heating | **After Heating at 190F, 20 mins.**



Starch-based pulping agent

Instant starch-based pulping agent

Ingredion

FUNCTIONAL PROPERTIES

Control and reduced tomato paste prototype have same functional properties in application

CO-TEXTURIZER FOR FAT MIMETIC

Concept of co-texturizer

- Starch based ingredients that **do not add to the viscosity** of the product, but instead provide **fat mimetic** characteristics that help **enhance the creaminess** of a product

Ingredion

OIL REDUCTION IN SPOONABLE DRESSING

Ingredient	40% Oil (%)	20% Oil (%)
Sugar	9.80%	9.80%
Starch 1 for viscosity	**2.70%**	**4.32%**
Salt	1.20%	1.20%
Mustard Powder	0.04%	0.04%
Sodium Benzoate	0.03%	0.03%
Calcium Disodium EDTA	0.03%	0.03%
Potassium Sorbate	0.01%	0.01%
Starch 2 for mouthfeel	0.00%	**0.33%**
Water	30.94%	49.74%
Vinegar (50 Grain)	10.00%	10.00%
Paste Sum	*54.75%*	*75.50%*
Paste	54.75%	75.50%
Egg Yolk (10% salted)	5.25%	4.50%
Vegetable Oil	**40.00%**	**20.00%**
Total	100.00%	100.00%

40% Oil	20% Oil
Oil, water, vinegar, sugar, egg yolks salted, **modified corn starch,** salt, mustard powder, sodium benzoate, calcium disodium EDTA, potassium sorbate	Water, oil, vinegar, sugar, **modified corn starch,** egg yolks salted, salt, mustard powder, sodium benzoate, calcium disodium EDTA, potassium sorbate

✓ **Same list of ingredients**

Approach:
a base **viscosifier** to build back some of the viscosity lost when the oil is reduced and then add a **co-texturizer** to enhance creaminess

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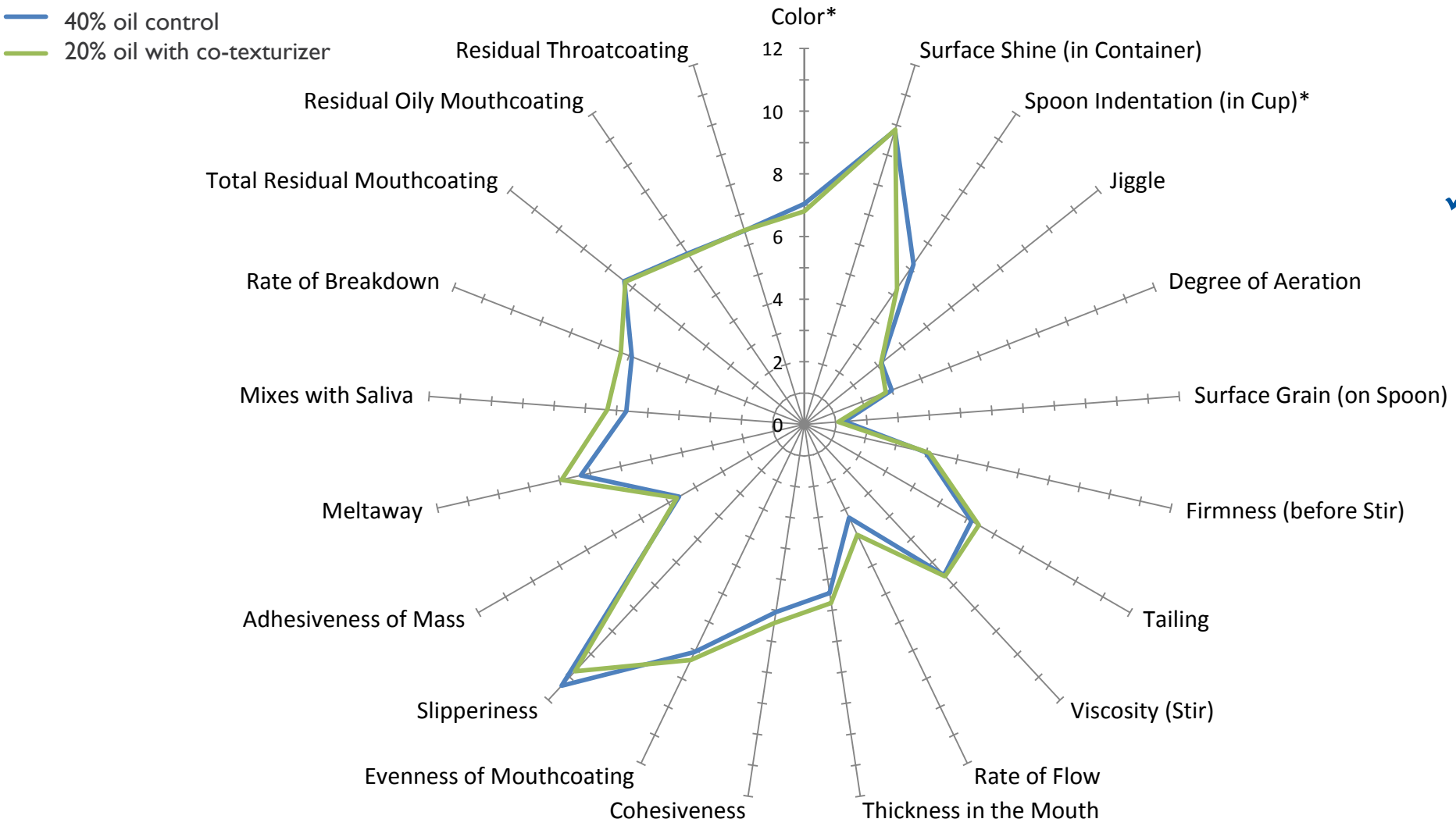
OIL REDUCTION IN SPOONABLE DRESSING



✓ **Similar Sensory Profile**

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OTHER APPLICATIONS WHERE STARCH IS IMPORTANT

Retort

- ✓ Typical Usage levels 2-5%
- ✓ Process tolerance
- ✓ Suspension aid
- ✓ Fill viscosifier
- ✓ Little to no residual viscosity in final product
- ✓ Heat resistance

Dry mixes

- ✓ Typical Usage levels 1-3%
- ✓ Instant or cook up
- ✓ Highly process tolerant
- ✓ Various types of sources with varying modifications

Oil Plating

- ✓ Plate oil & liquids
- ✓ Liquids into powders
- ✓ 20-40% Loading
- ✓ Dry sauces
- ✓ Instant applications
- ✓ Better flowability
- ✓ Reduced hygroscopicity

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FUNCTIONAL STARCHES AND FLOURS FOR DRESSINGS AND SAUCES

1. **Large variety of flour & starch** ingredients for different functionality requirements
2. Select a product **that meets your** process & shelf life stability, texture, functionality, cost and labeling needs
3. **Optimal** temperature, mixing and shear **varies** on starch type and other ingredients
4. **Approach formulation challenges** with structural-functional understanding, formulation science and use resources from various sources such as ADS, and supplier technical resources

Ingredion

THANK YOU

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Developing ideas.
Delivering solutions.™

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IDEAS TO SOLUTIONS

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