

Random Extruder Redesign with Twin-Auger Conveyance to Enable Processing of Whole-Grain Rich Raw Materials

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*Dr. Jorge Morales is an employee of PepsiCo Inc.
The views expressed in this article are those of the author and do not
necessarily reflect the position or policy of PepsiCo Inc.*

Random extrusion is a significant business for PepsiCo



Technology has remained unchanged for over 65 years



Adams Corp launches first
ever fried, corn curls

1946

1990s

2014

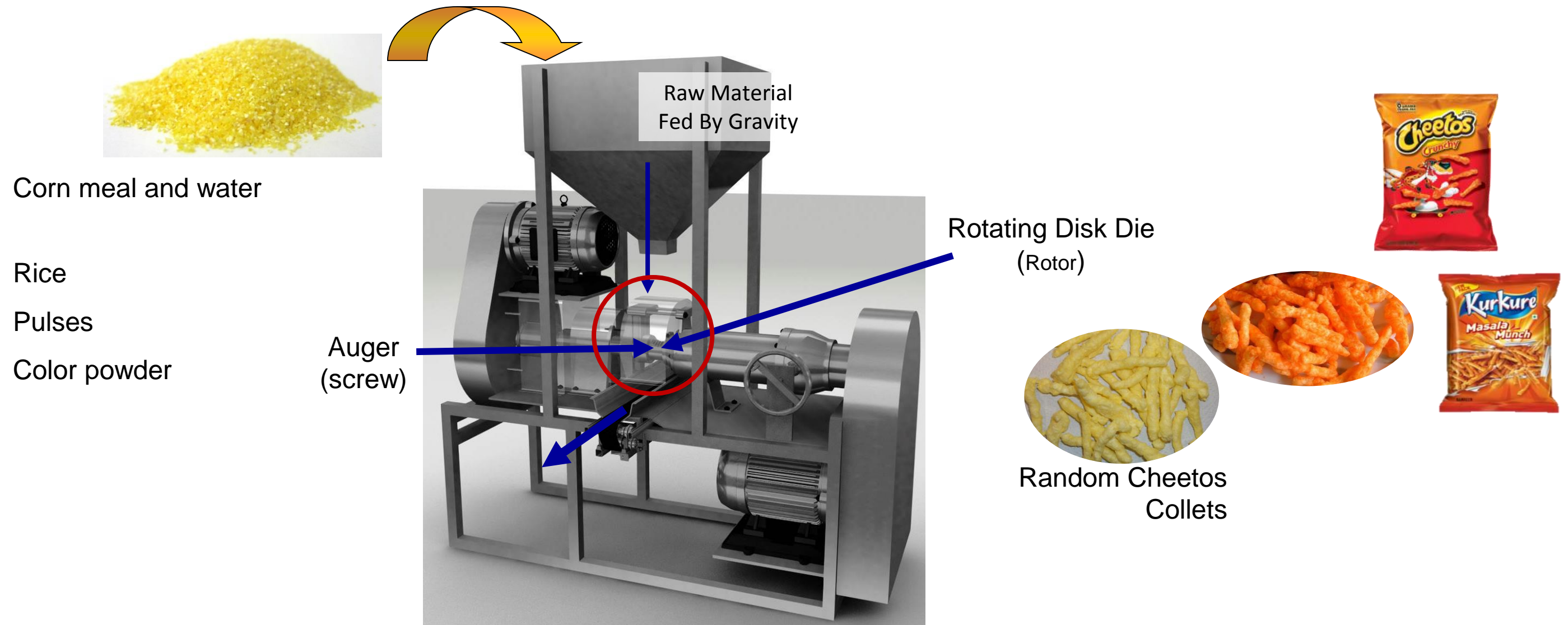
AREx
PepsiCo Fellowship



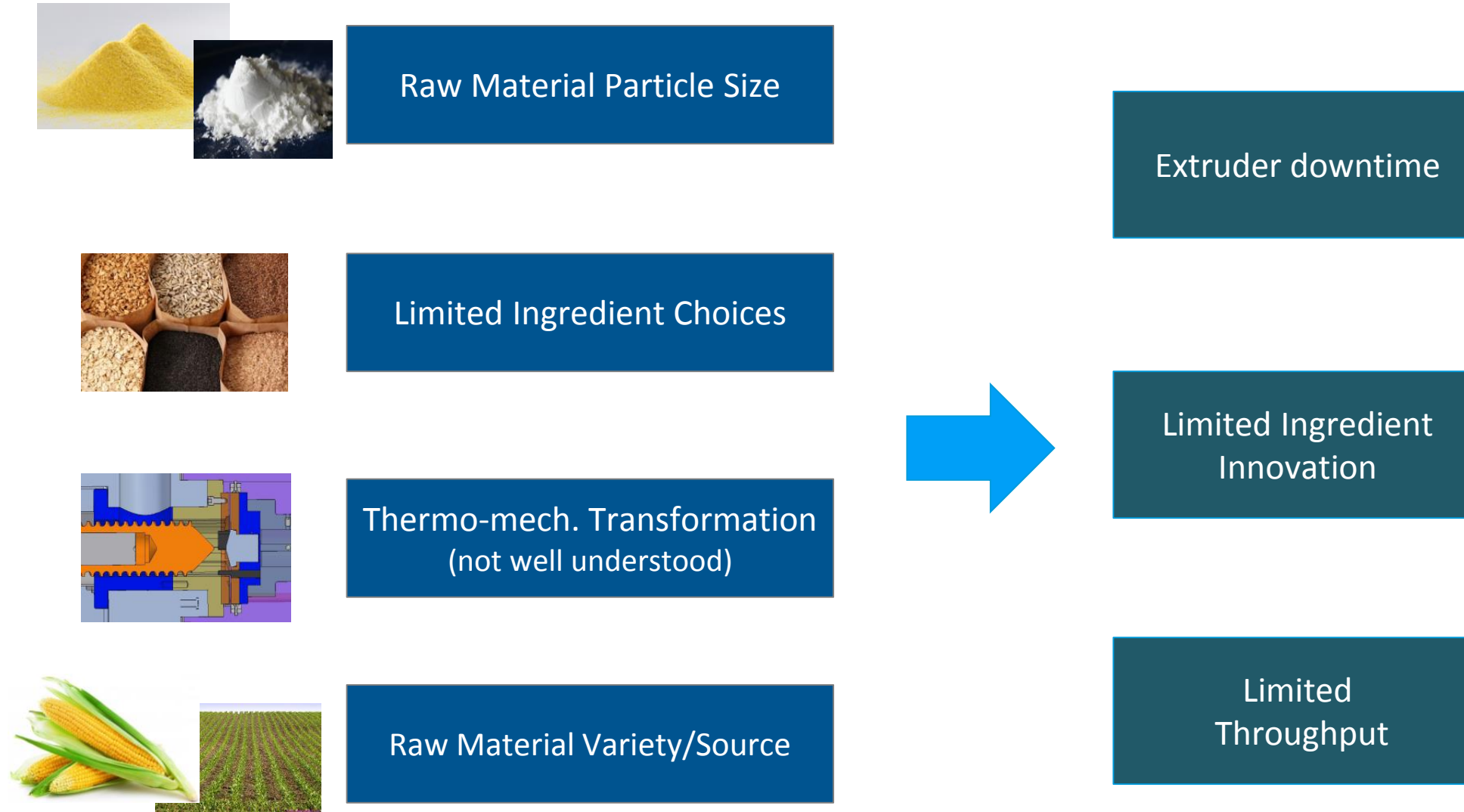
Rate Boost
(faster rotor, triple-flighted screw)



Random extruders process only refined cereal meals

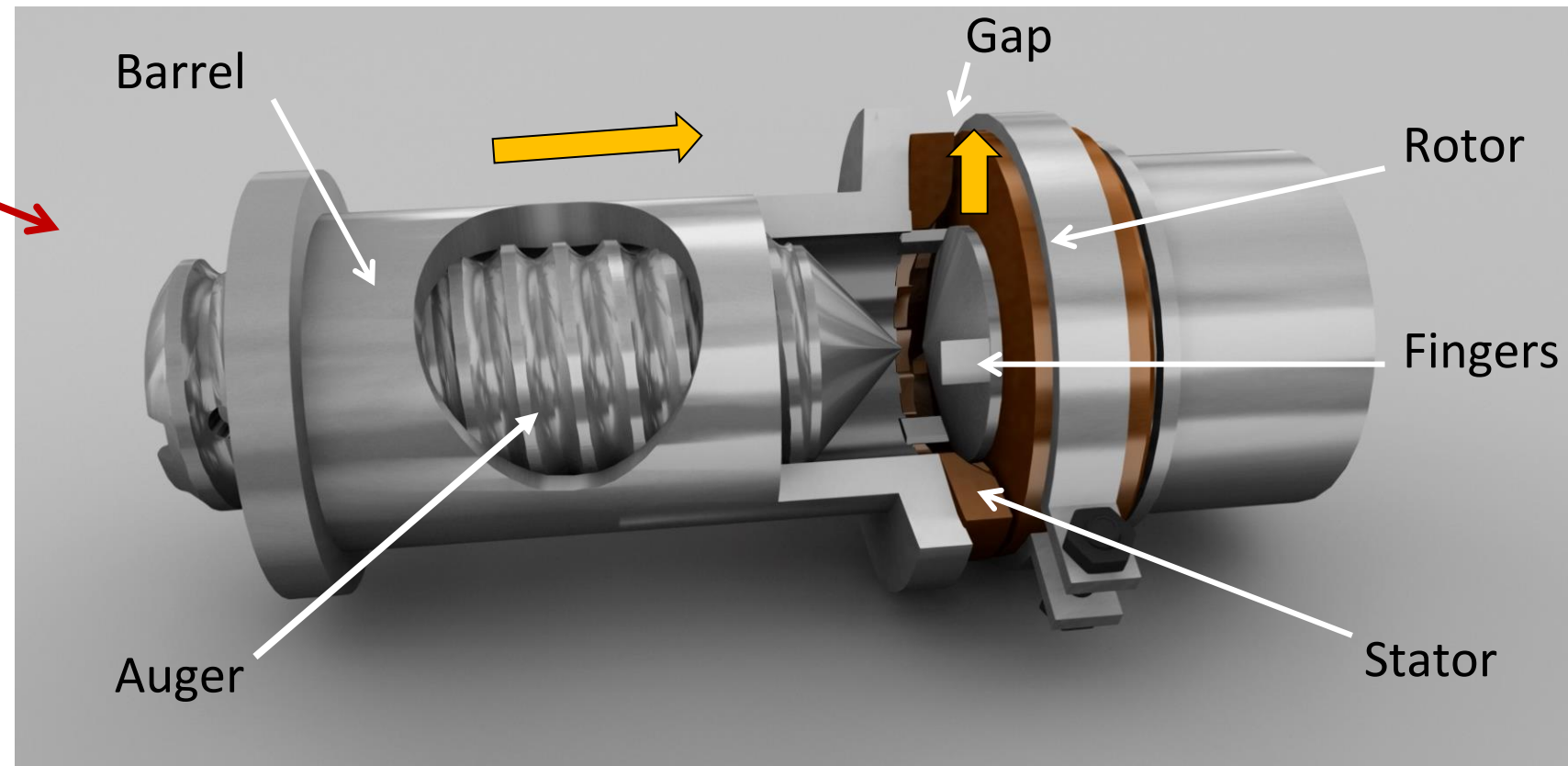
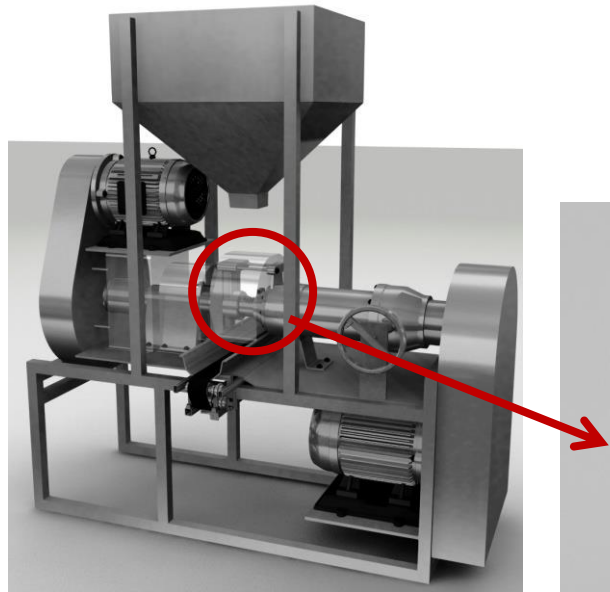


Known challenges and modes of failure

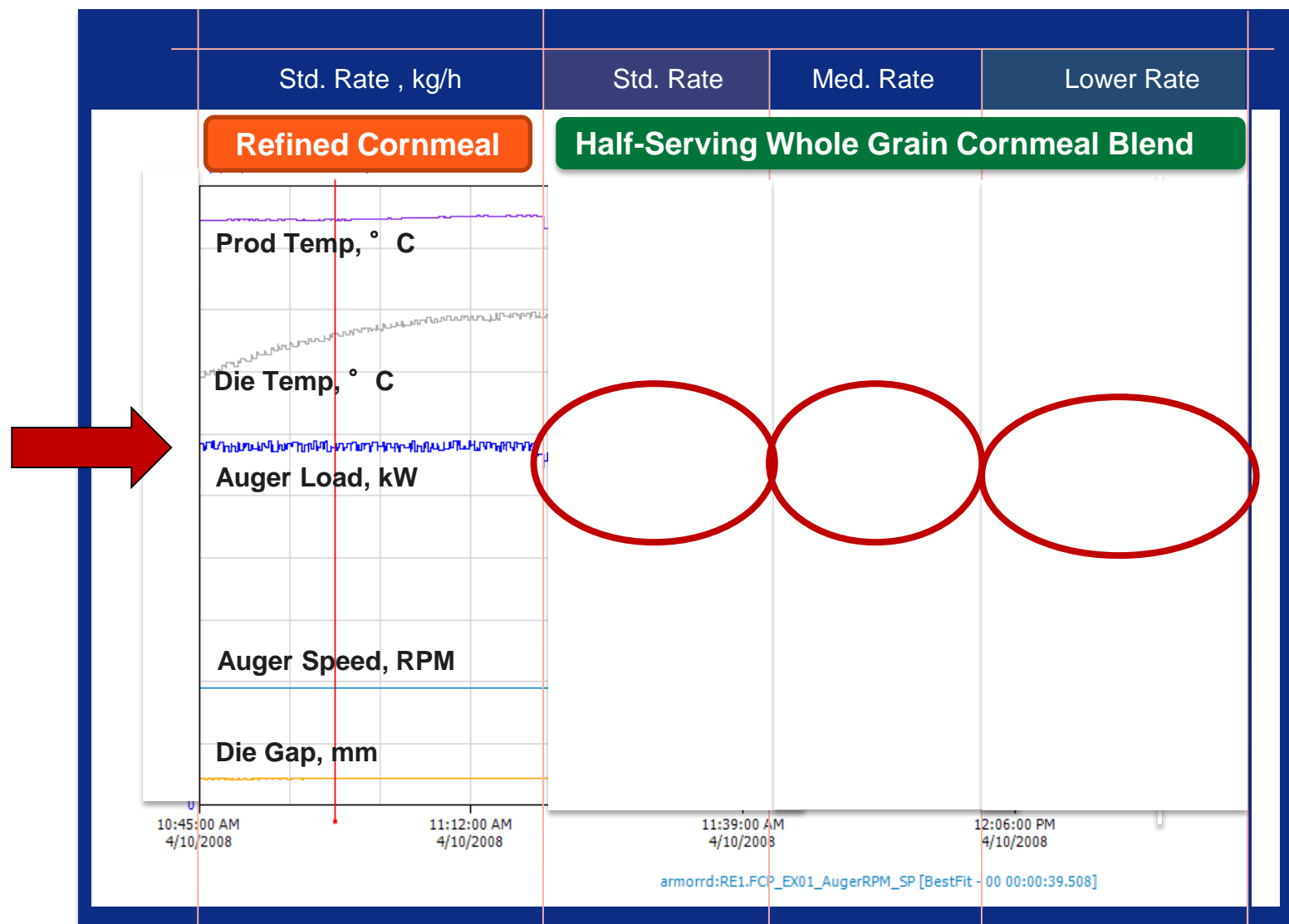


Conveyance and raw material transformation

- Changes in material fed cause failure

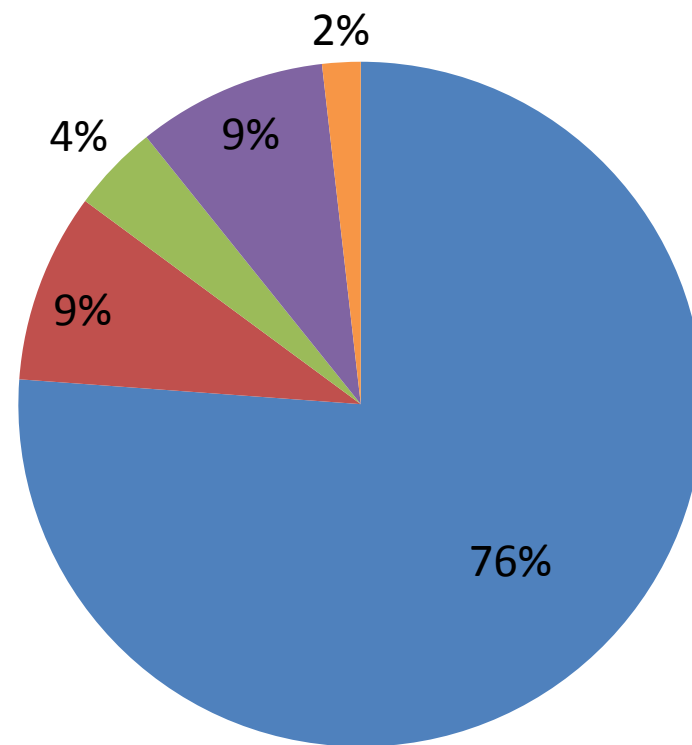


Raw material conveyance is major limitation

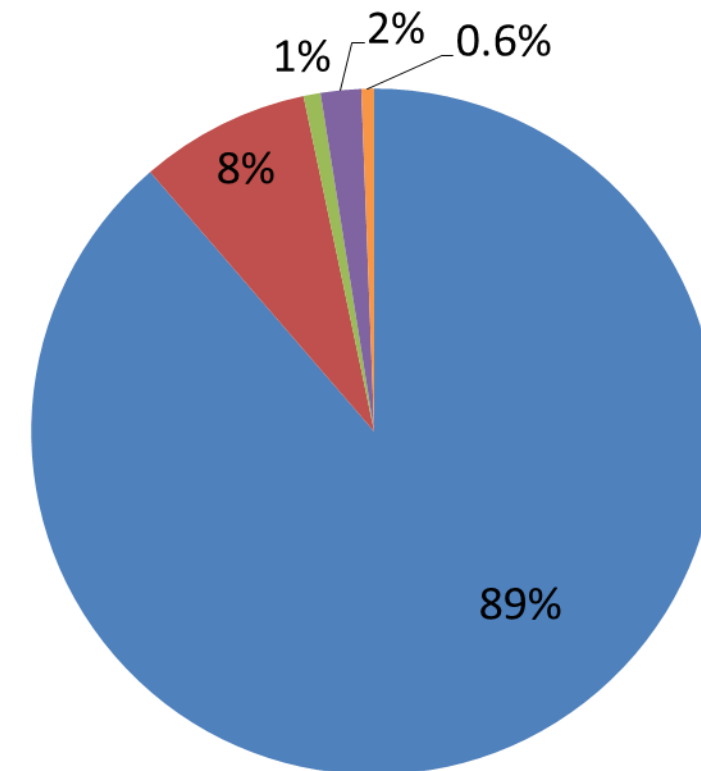


Whole-grain has higher lipids and fiber content

Whole-Grain Cornmeal

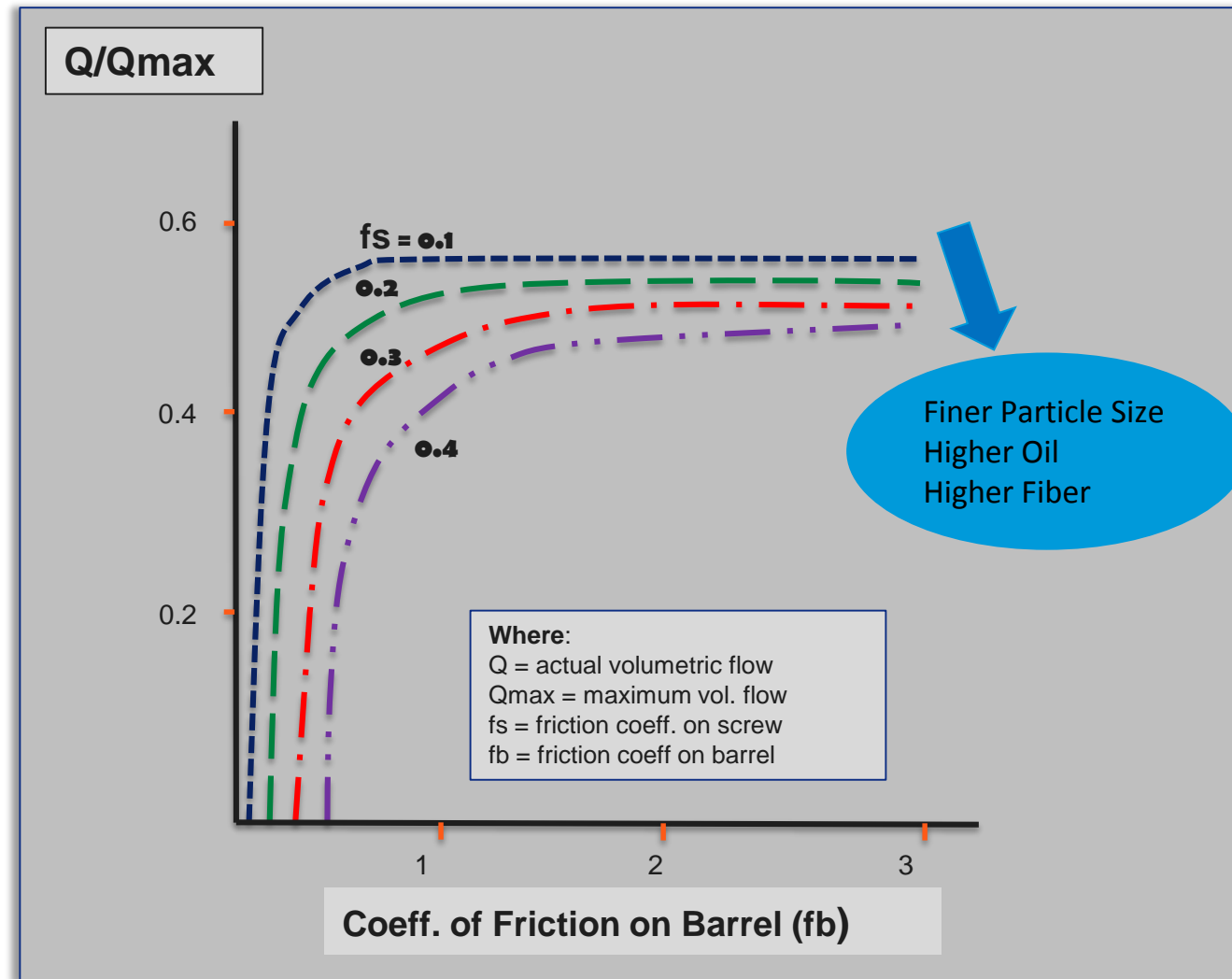


Refined Cornmeal



■ Starch
■ Protein
■ Fat
■ Fiber
■ Ash

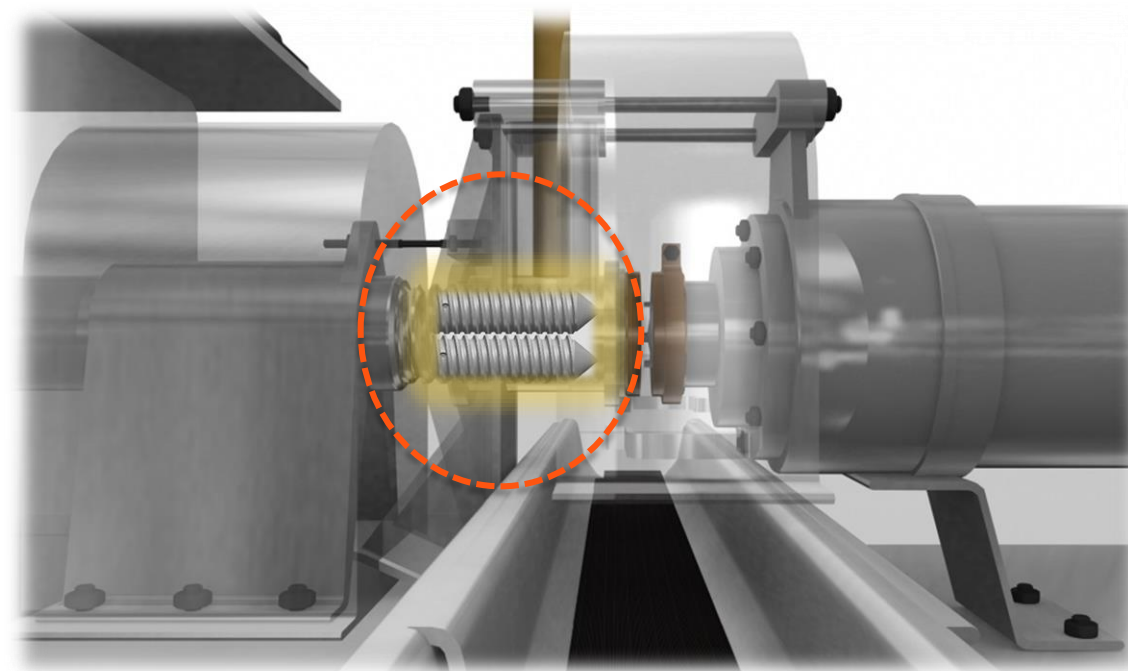
Current design is limited by reliance on friction differential for conveyance



Improved conveyance by redesigning Inlet / flow- path design

Advantaged Random Extruder (AREx) Twin-Auger Conveyance

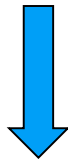
- Improved conveyance
- Self-wiping mechanism
- More robust with changes in raw material



US Patent US 9,669,574 B2 (J. Morales and M. Rao)

Deliver WG Crunchy Cheetos

Further improve health credentials of iconic brands



- ✓ Wholegrain rich
- ✓ 5 g of Fat
- ✓ 0 g Sat Fat
- ✓ ≤ 230 mg Na



1

Robust engineering design: standard cornmeal and whole-grain cornmeal

2

Developed consumer winning Whole-Grain Baked-Crunchy Cheetos

3

Validate capability to deliver existing Fried Crunchy and Baked! Crunchy products

Phase 1 - Ensure robust engineering design delivering stable process

Process Variables

- Feed rate
- Auger speed
- Rotor speed
- Die gap
- In-barrel moisture

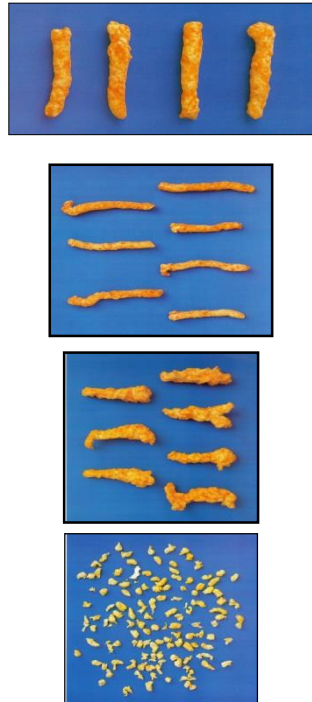
Noise Variables

- Cornmeal particle size
- Cornmeal Intrinsic Moisture

AREx Process

Response

- Bulk Density,
- Defects
 - Skinnies
 - Clubs
 - Bits & Pieces



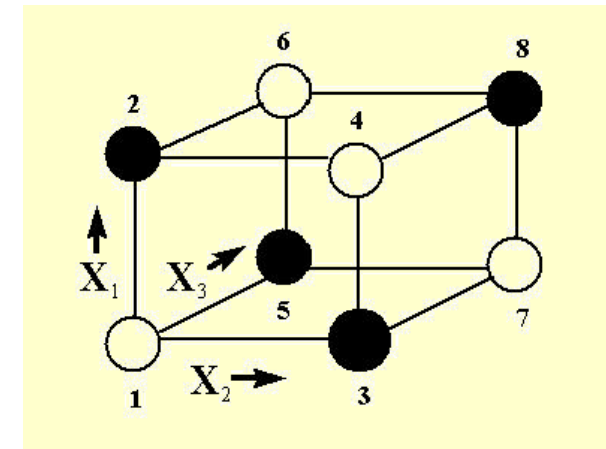
Taguchi Method

- Center measured quality characteristic around target value
- Minimize variation around target value

Phase 2 – Leveraged robust process parameters on whole-grain to develop consumer-winning product

Independent Variables
Feed Rate (lbs/hr)
Augur Speed (rpm)
Rotor Speed (rpm)
Gap (in)
In Barrel Moisture (%)

For 5 factor $\frac{1}{2}$ factorial
design $n = \frac{2^5}{2} = 16$

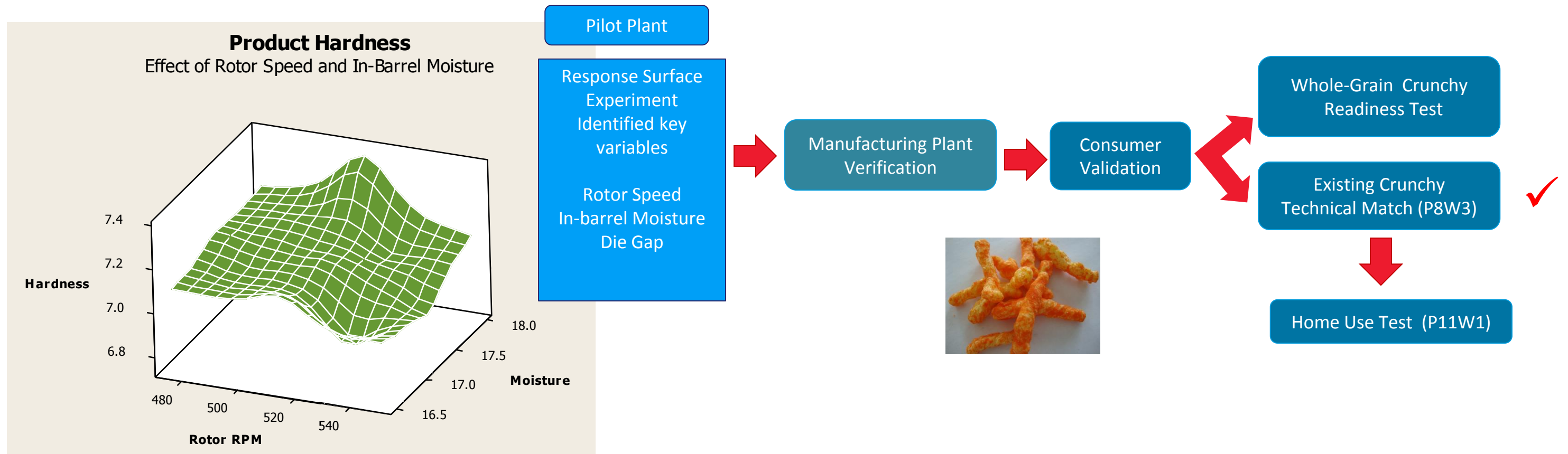


Several samples generated for consumer testing

Results from consumer testing helped frame process conditions to deliver on most desirable product attributes

Phase 3 - Validate capability in manufacturing plant for in-market product and new whole-grain product

- ✓ Extended test in plant
- ✓ Optimization of product texture attributes and plant verification
- ✓ Consumer testing to match existing product in market

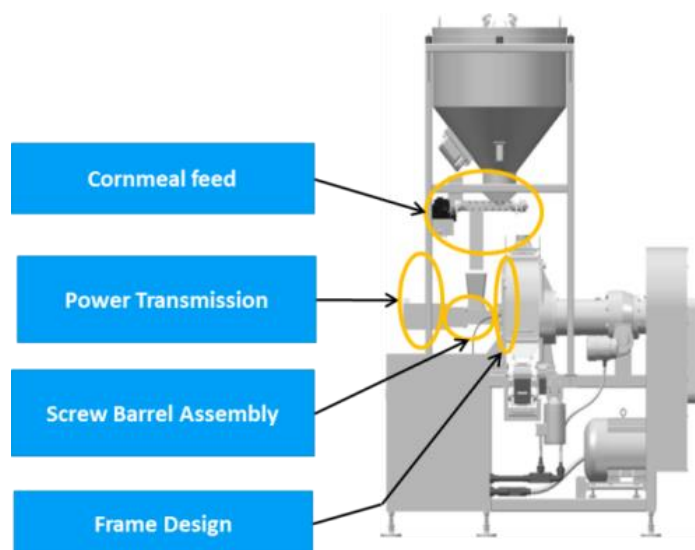


Commercializing AREx required significant development

Process and equipment design and development

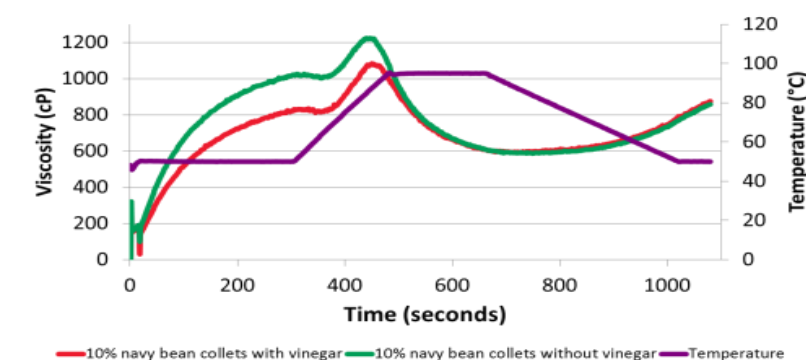
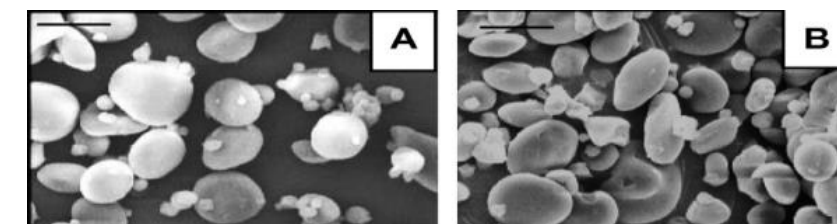
Consumer validation

Wholegrain Ingredient analysis and testing



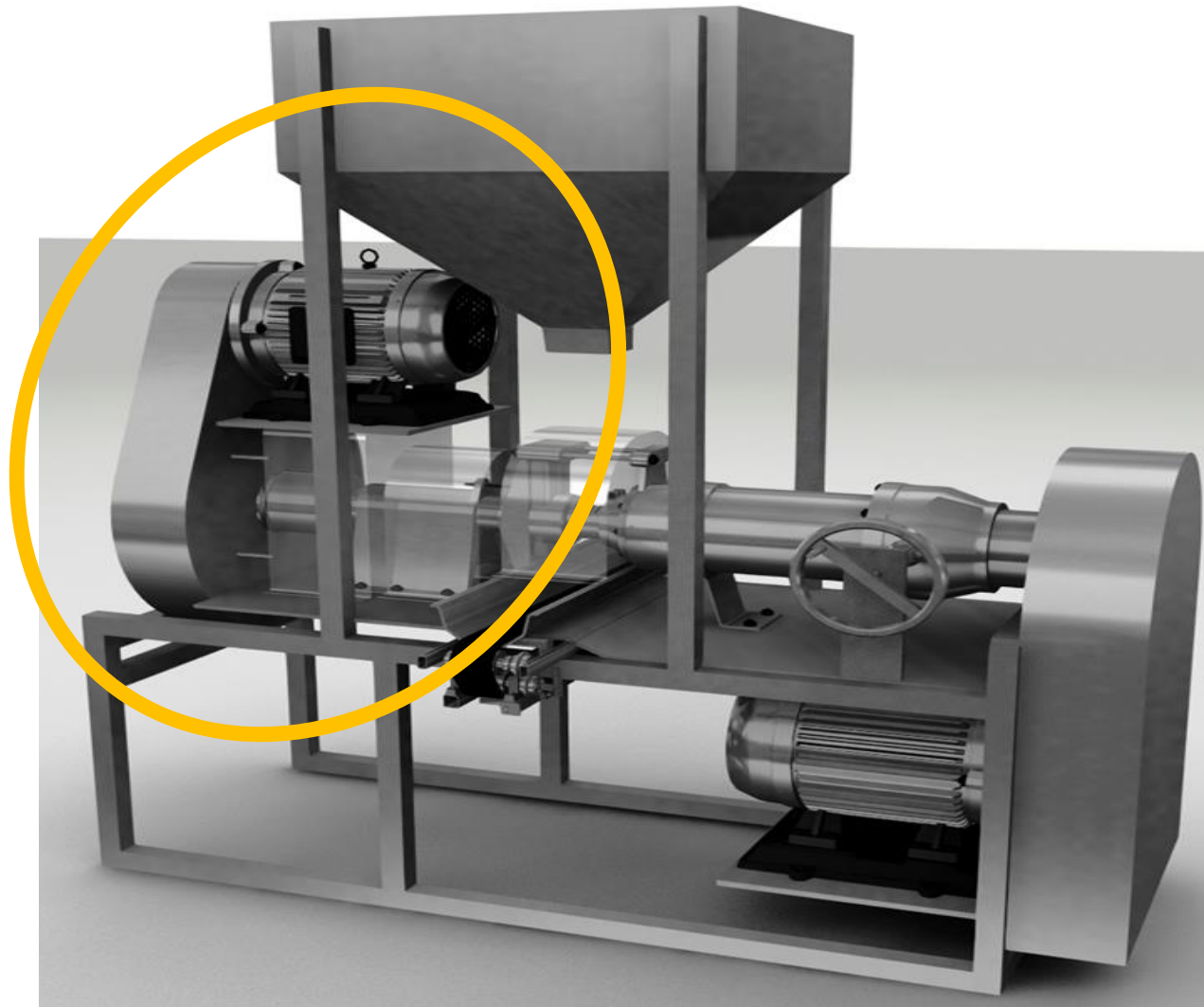
Technical match for
core products

Equal Liking for WG
baked products

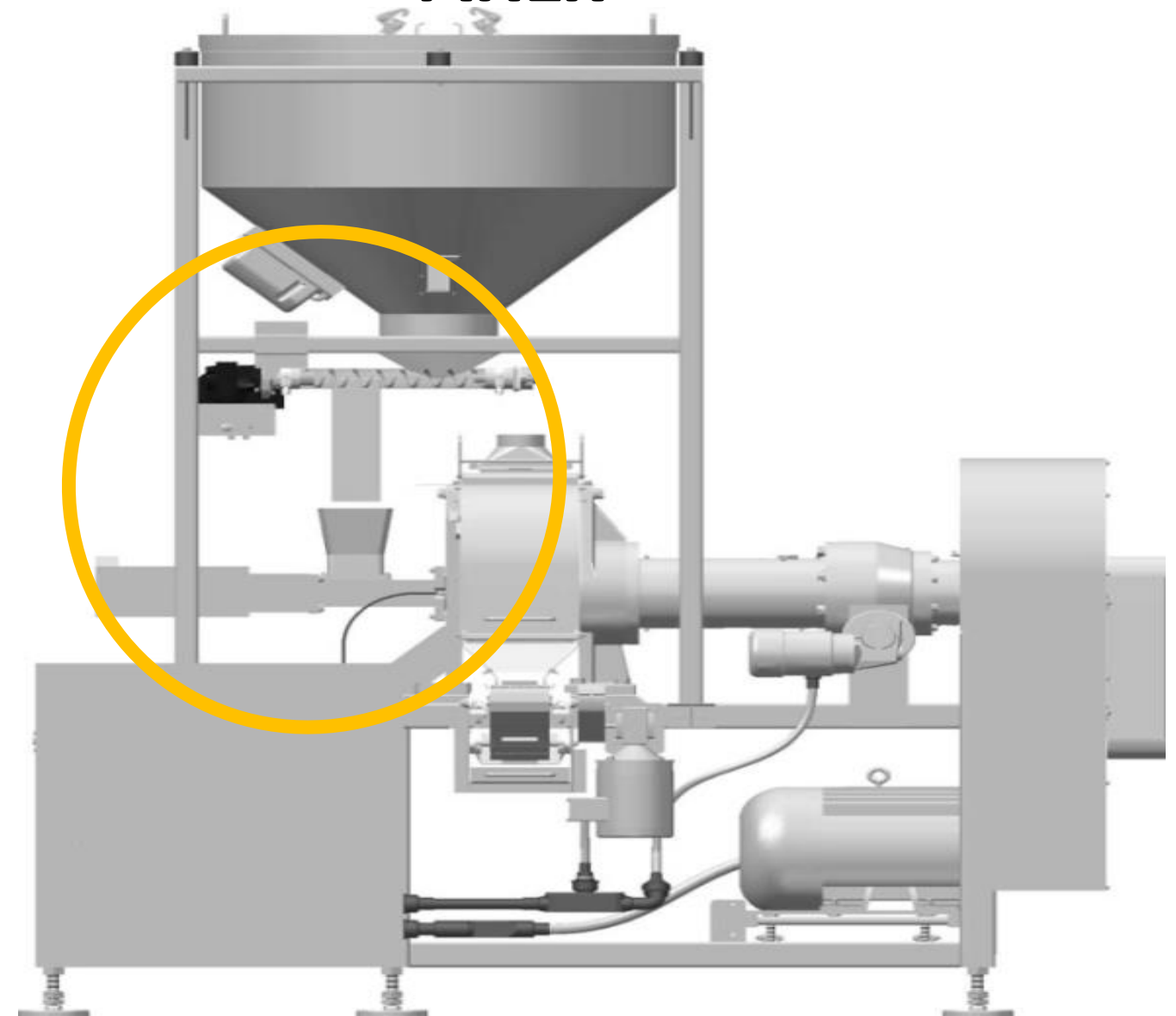


Significant mods required to standard random extruder

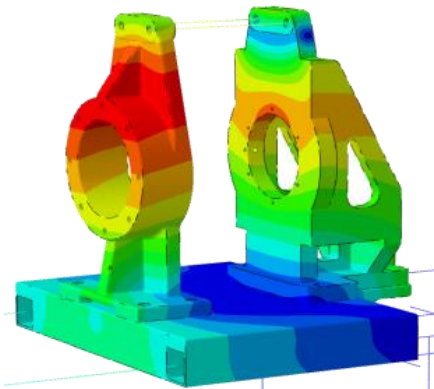
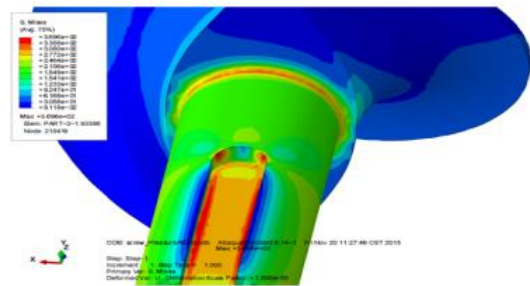
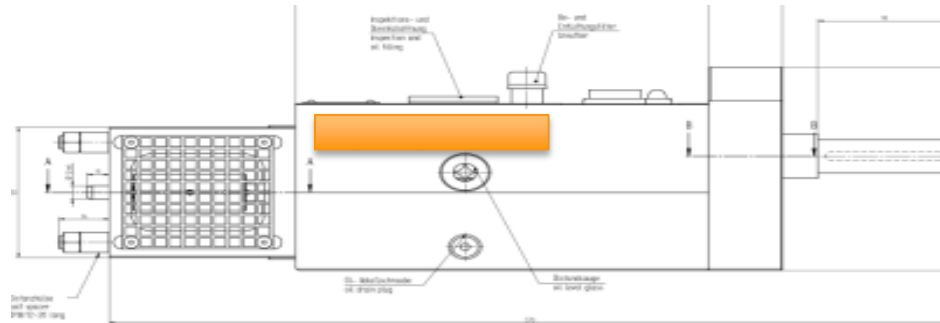
Random Extruder



AREx



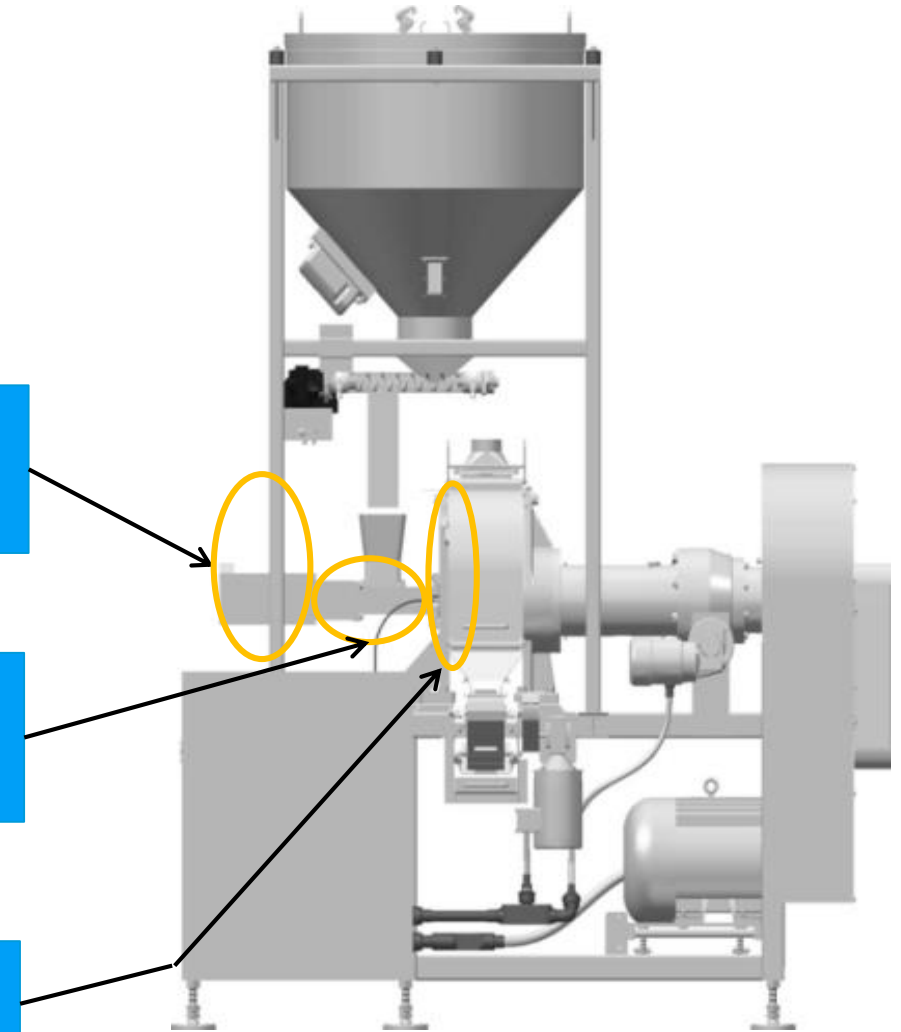
Each design aspect thoroughly evaluated for robustness



Power Transmission

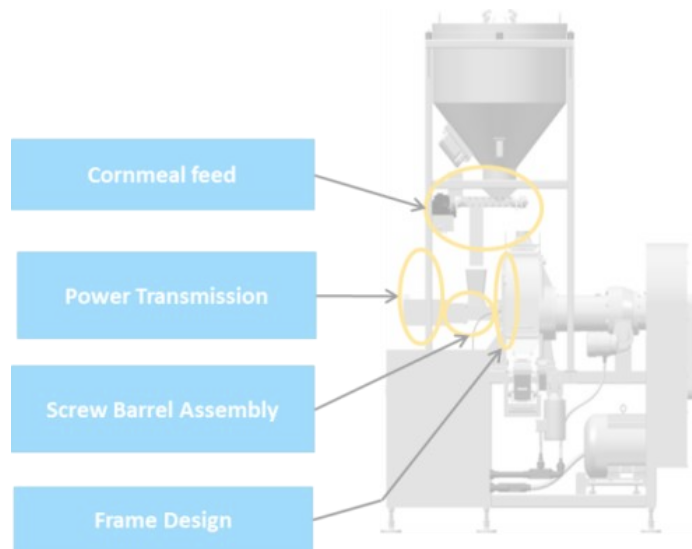
Screw Barrel Assembly

Frame Design



Commercializing AREx 1.0 required significant development

Process and equipment design and development

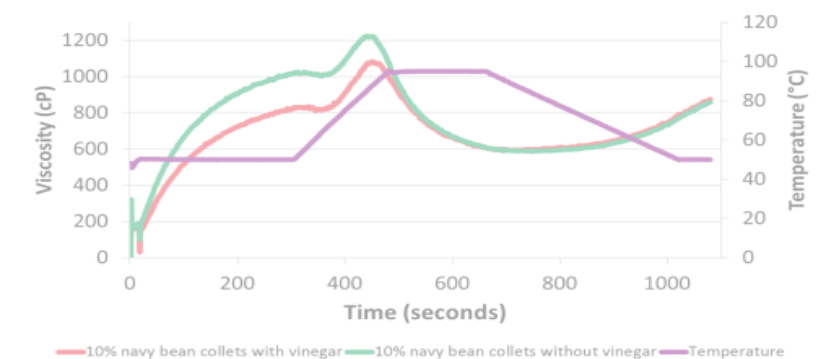
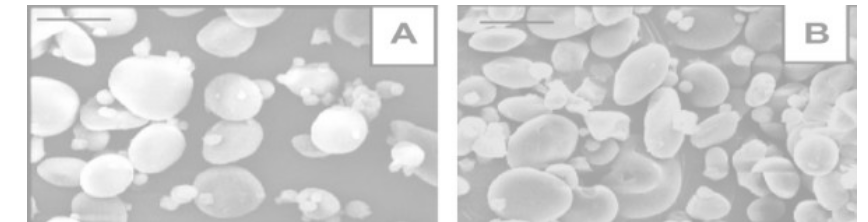


Consumer validation

**Technical match for
core products**

**Equal Liking for WG
baked products**

Wholegrain Ingredient
analysis and testing



Successfully validated all products within the timeline

Proved the ability to deliver existing fried and baked crunchy products, using Technical Match sensory protocol

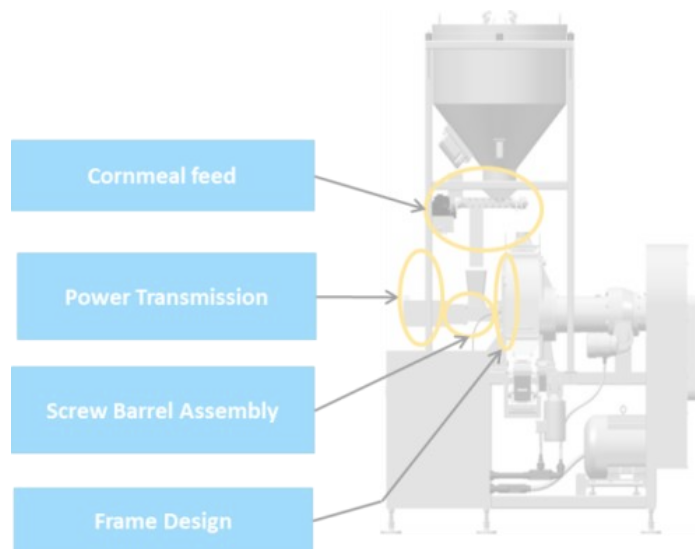


Fried Mellow Cheddar					Conducted with WG launch
Fried Flaming Hot					
Baked Mellow Cheddar					
WG Baked (MC & FH)			Equal Liking vs. non-WG w/ kids		

- Monitor for extended time*
- *Product quality*
 - *Consumer contacts*
 - *Operational efficiency*

Commercializing AREx 1.0 required significant development

Process and equipment design and development

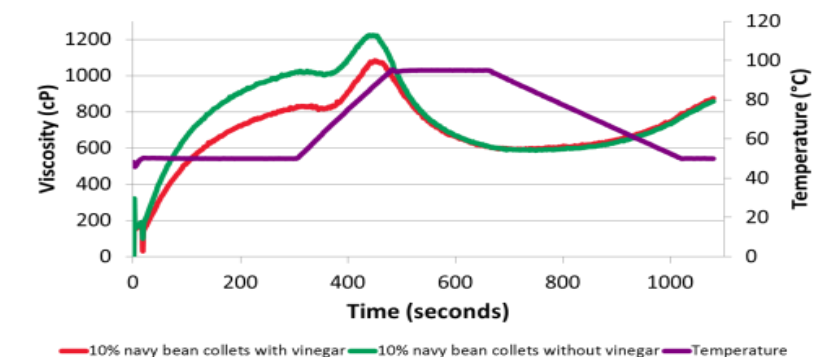
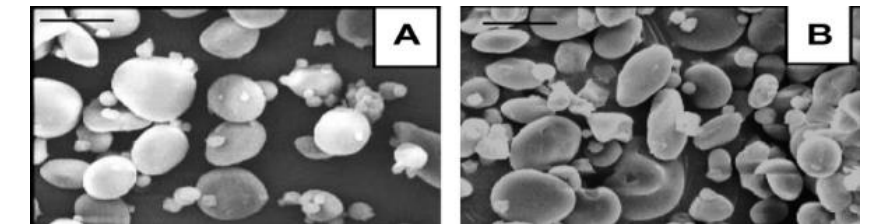


Consumer validation

Technical match for
core products

Equal Liking for WG
baked products

Wholegrain Ingredient
analysis and testing



Operational experience has led to further improvements in process and mechanical robustness

Ingredient Delivery

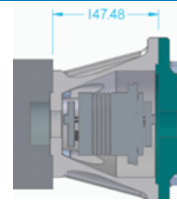


Hopper and Feed Auger



Barrel Design

Increasing screw Integrity

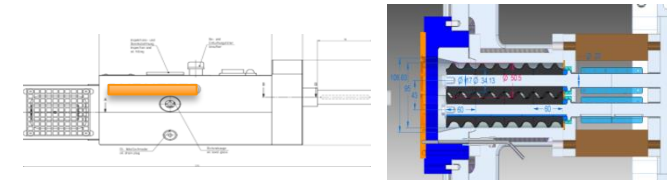


Mechanical Limiter



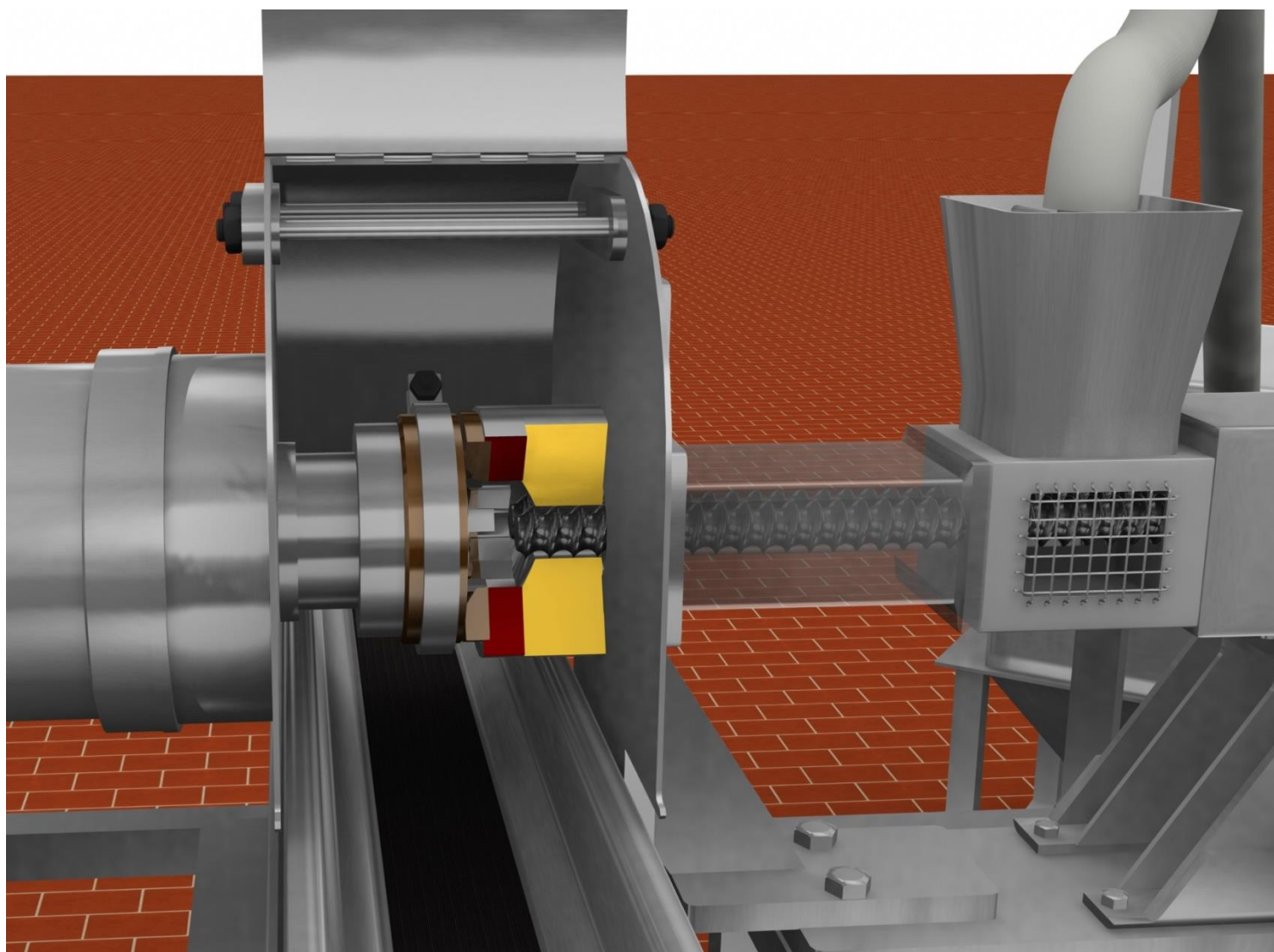
Over Torque Stress

Increasing mechanical robustness



Gearbox Supplier
Sustainability

Future is Bright



Near Term

- Launch WG Baked Crunchy in US

Longer Term

- Better understanding of thermo-mechanical transformation
- Capacity
- Ingredient Innovation
- Look to apply technology in other international markets

