

FOOD & WINE

**DESTINATION
UNPLUGGED**
7 TRIPS
OF A
LIFETIME

The healthy
secrets
of this
irresistible
chocolate
cake?
Check out
p. 45.



**EAT
SMARTER
LIVE
LONGER**

72 GENIUS RECIPES & HACKS
FROM THE PROS

FEBRUARY 2017

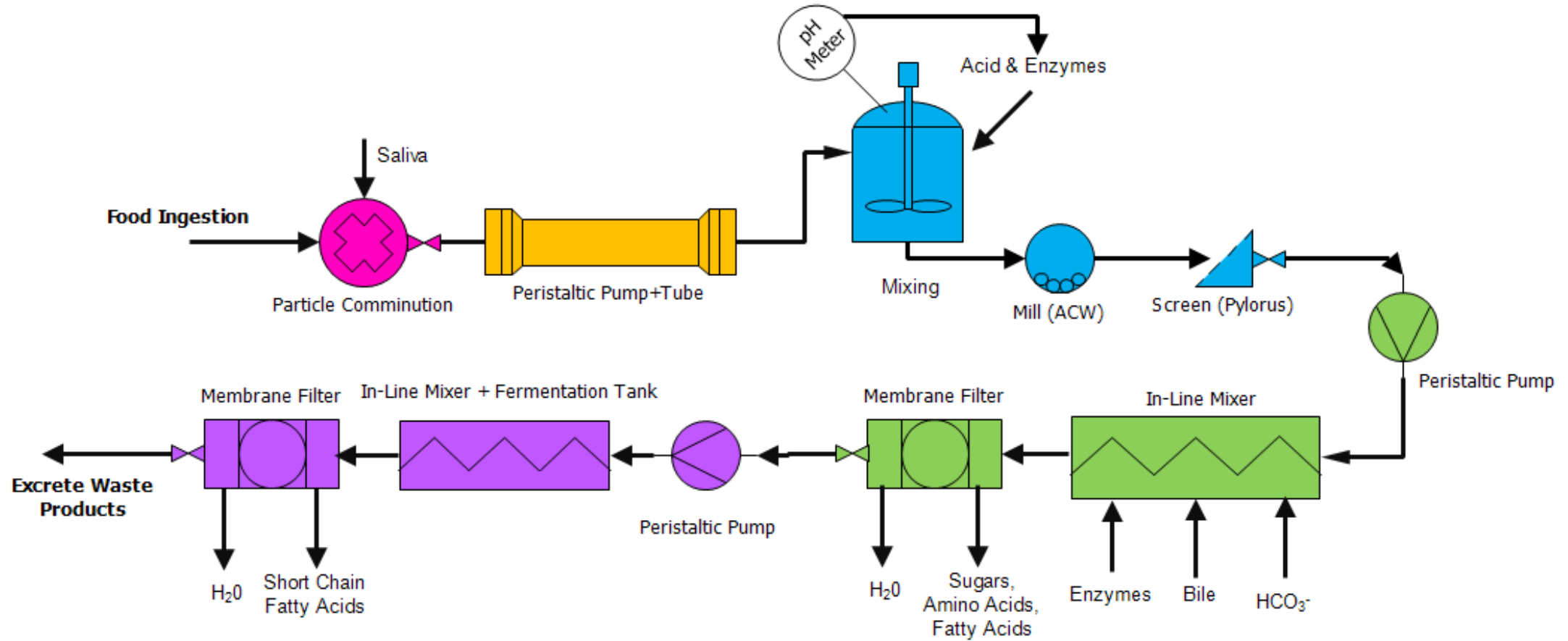
+

**IS TEQUILA
GOOD FOR
YOU?**



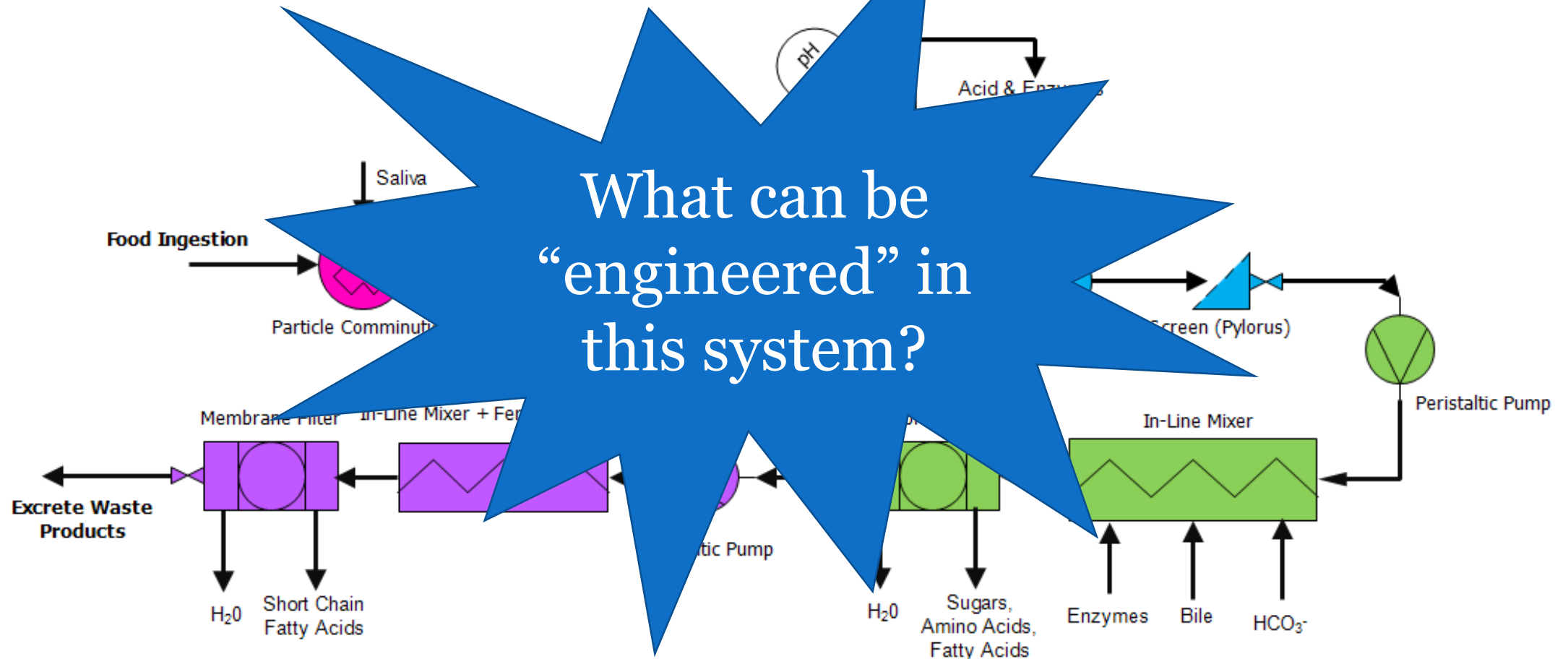
Engineering Operations during Digestion

Gastrointestinal Digestion Process Flow Diagram



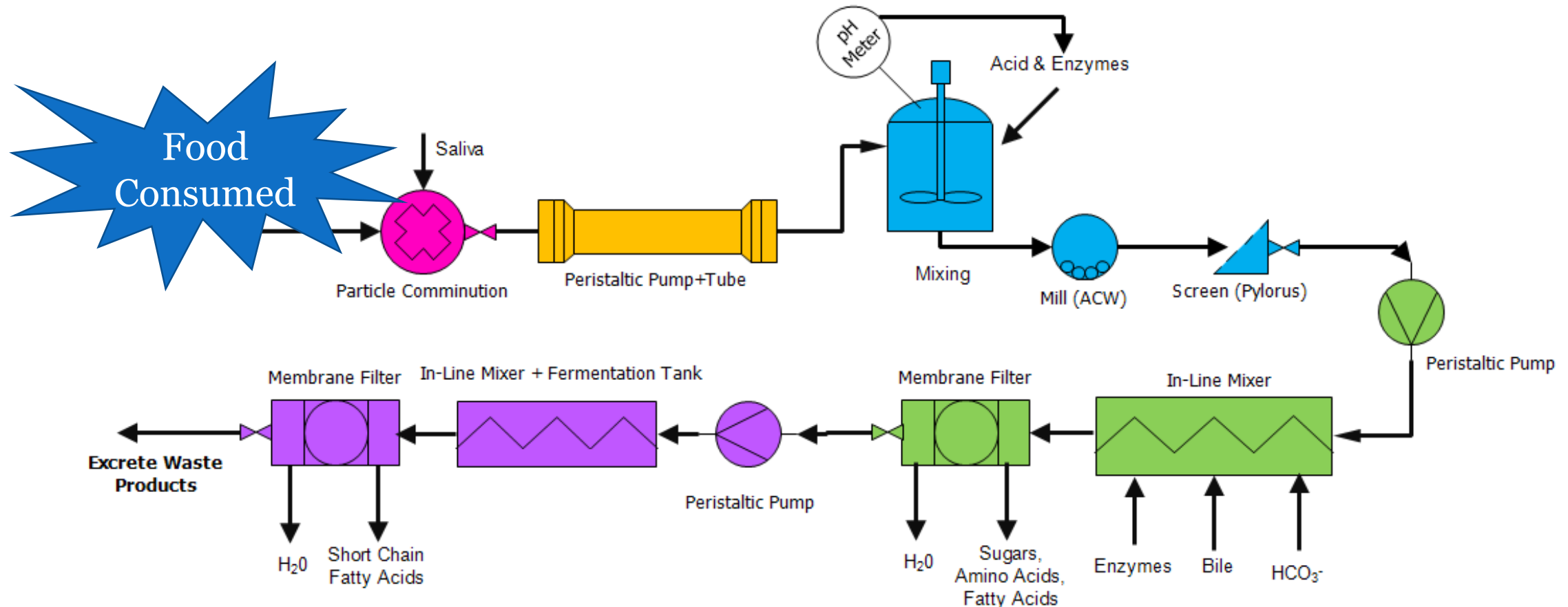
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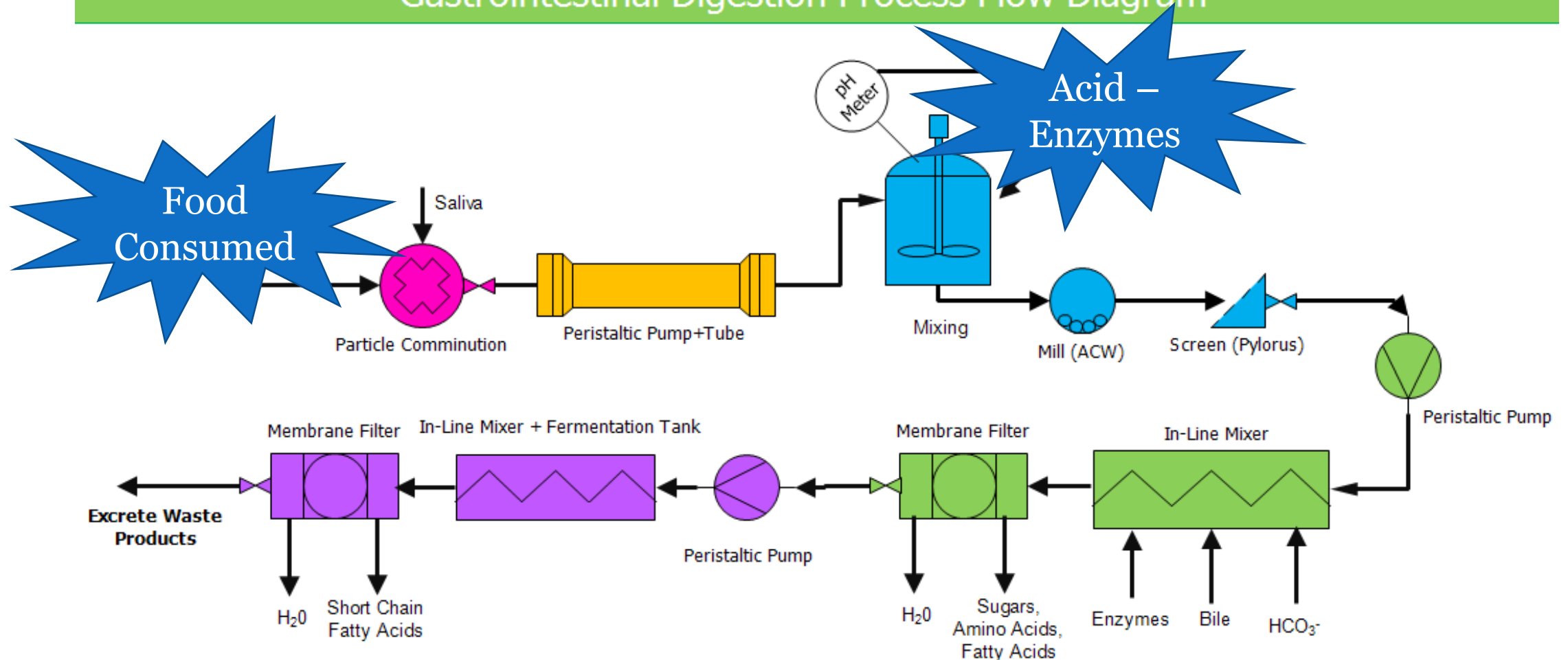
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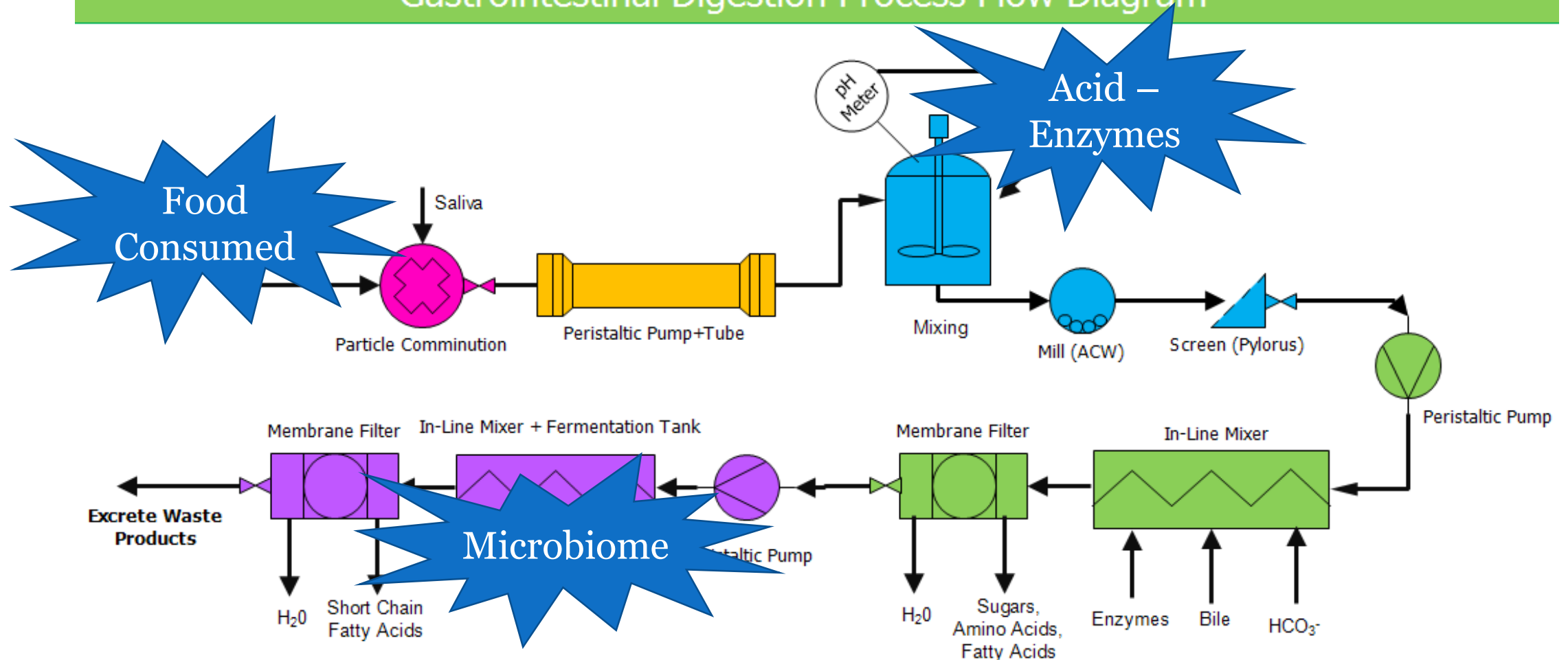
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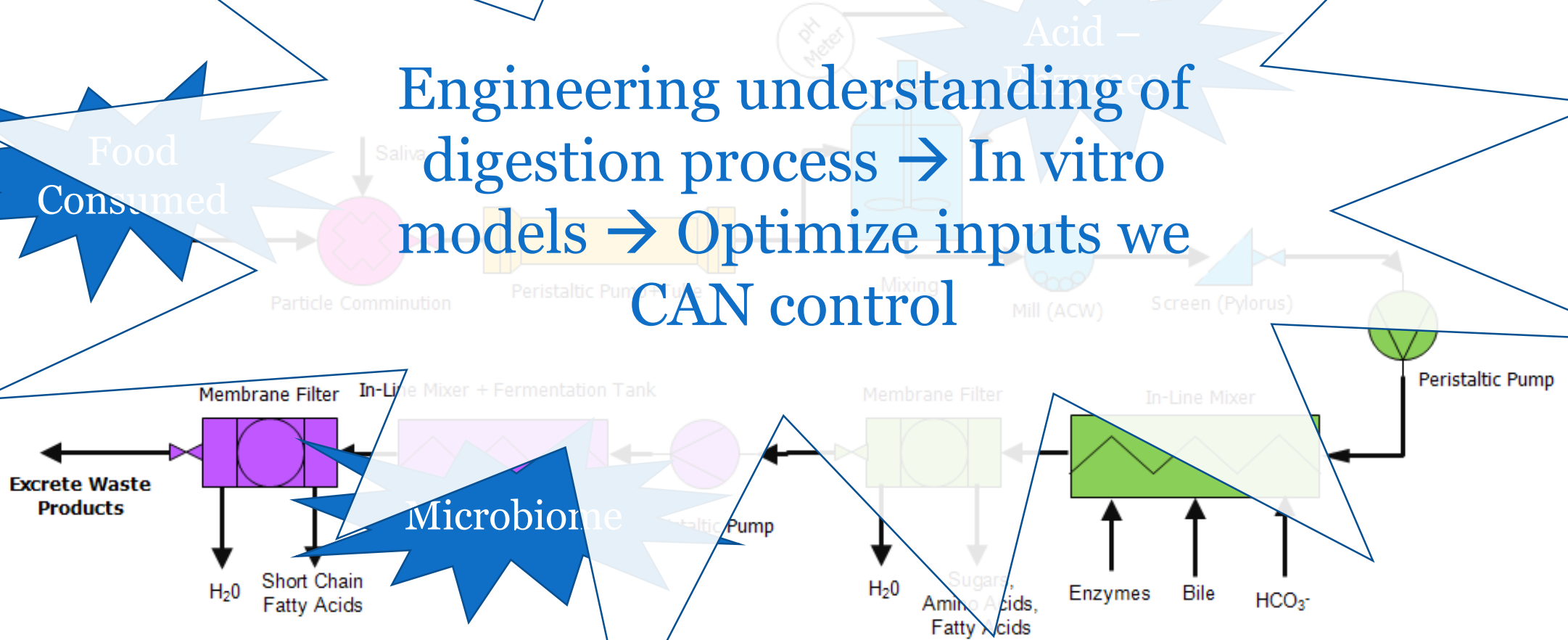
Gastrointestinal Digestion Process Flow Diagram



Engineering Operations during Digestion

Gastrointestinal Digestion Process Flow Diagram

Engineering understanding of digestion process → In vitro models → Optimize inputs we CAN control



Engineering Opportunities for In Vitro Gastric Models

- Gastric secretions
 - Rate vs. pH → Control systems and sensors
- Gastric emptying
 - Valve development
 - Adaptive control systems
- Forces
 - Variable control depending on food
 - How to correlate with in vivo?
- Adaptive relaxation
 - Flexible polymers
 - External volume control

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Pylorus from
pig stomach



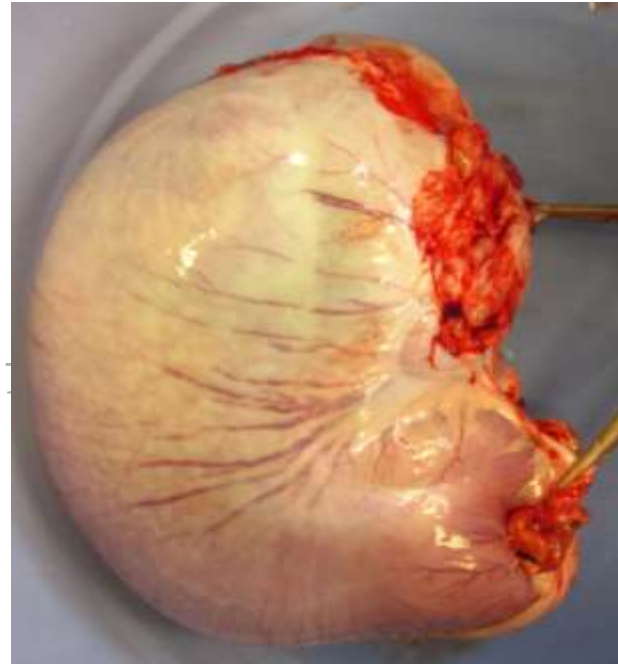
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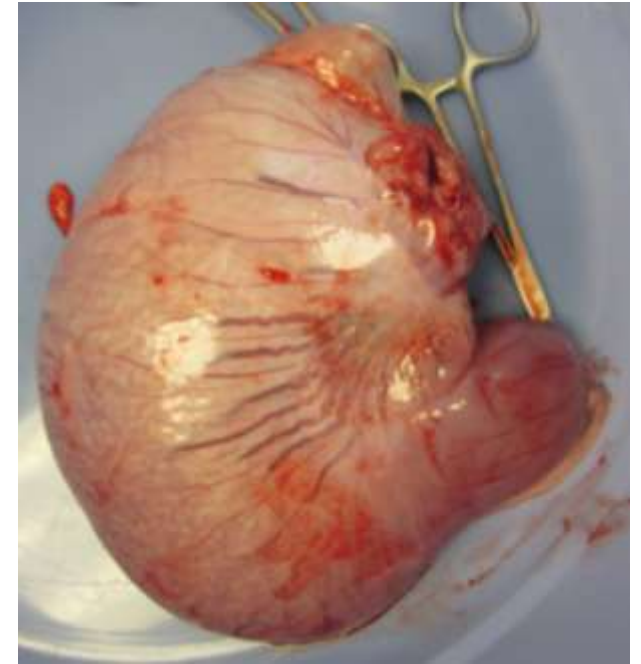


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20 min digestion time
~ 90% initial dry matter



8 hours digestion time
~17% initial dry matter

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Takeaway Messages:

Physiological control systems are complex

Many opportunities to implement **engineering control systems, sensors, and materials** in digestion models!

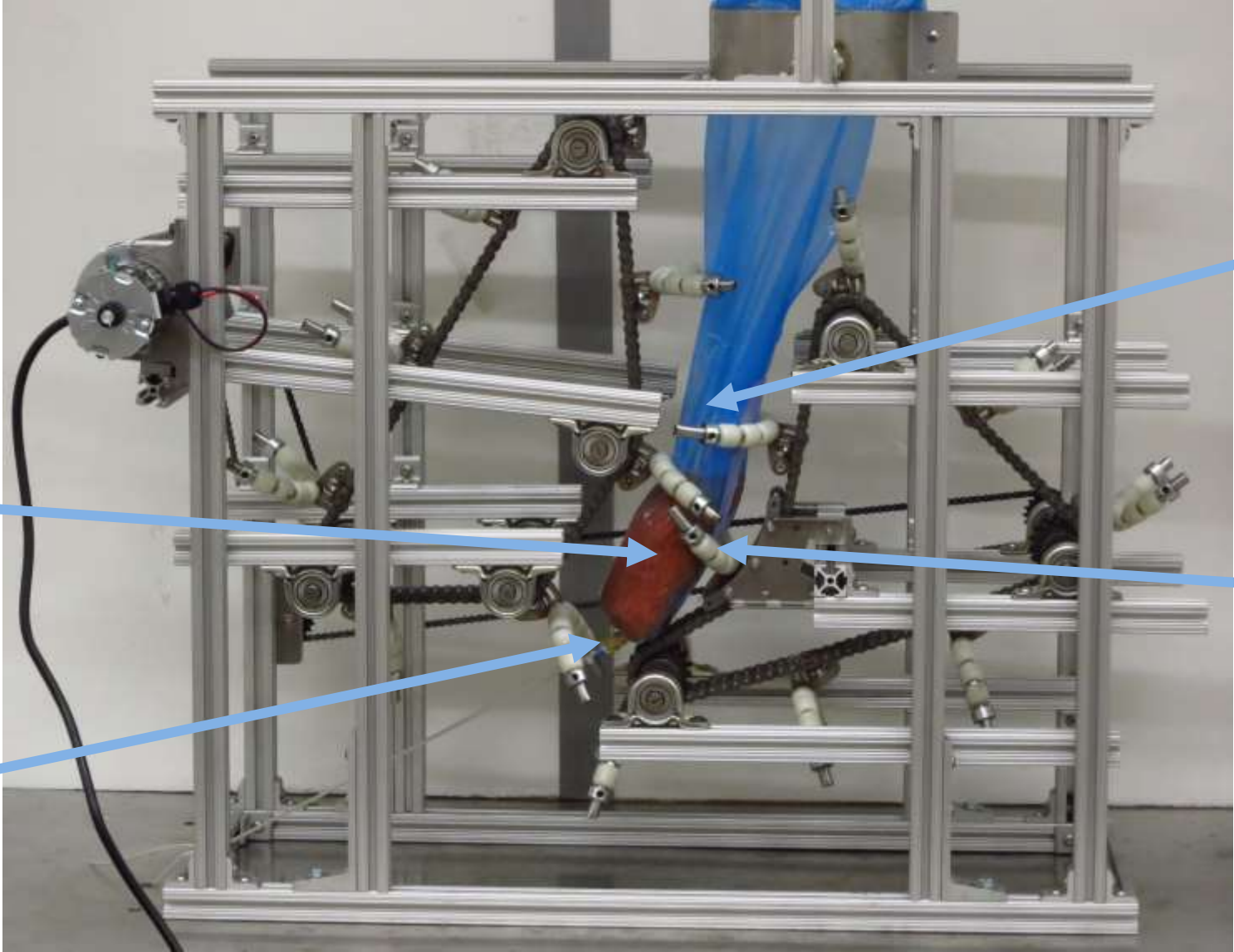


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How to incorporate some of
these features into a gastric in
vitro model?

Dynamic Model: Human Gastric Simulator v2.0



Test Meal
~200-400 g

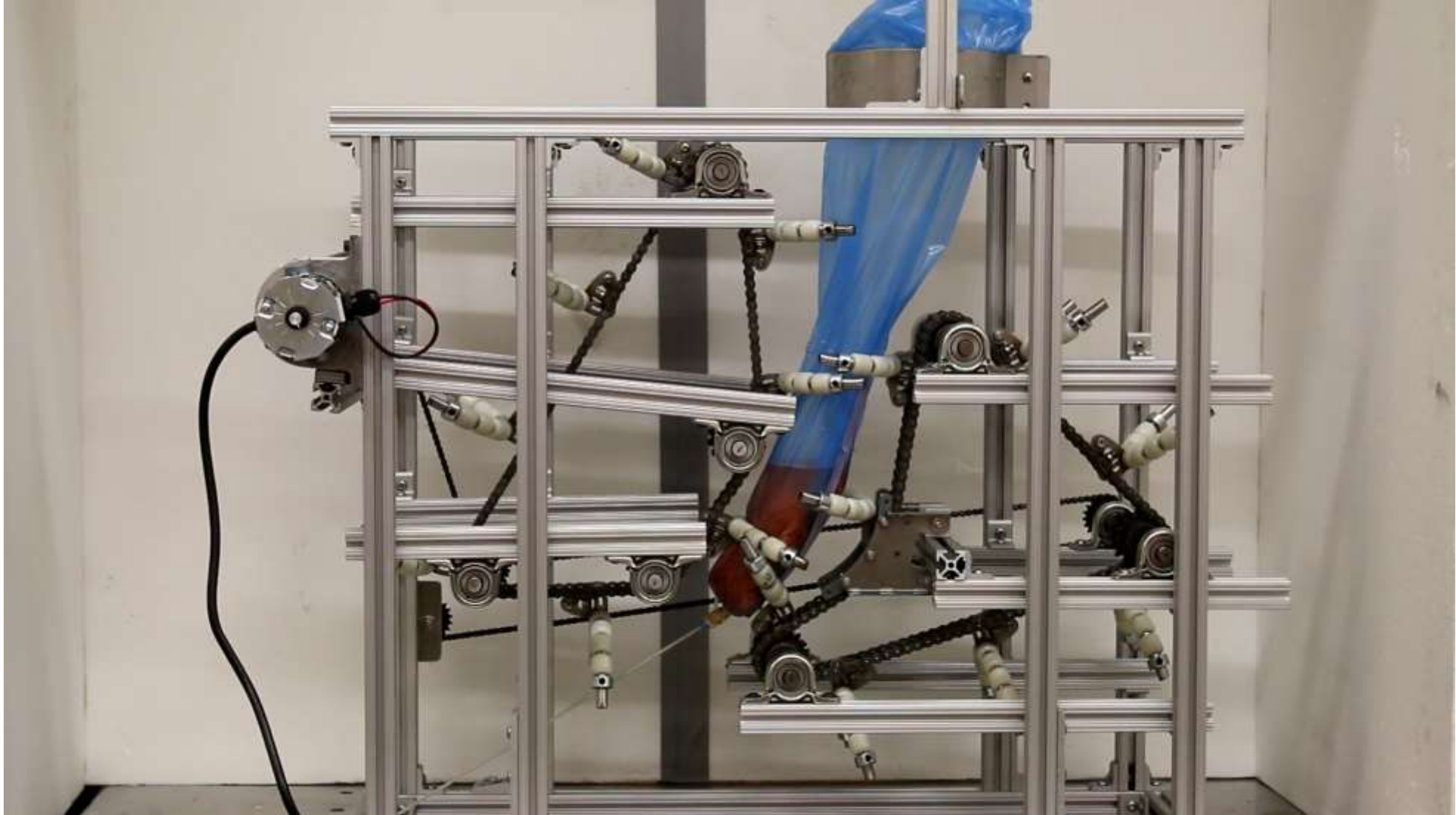
Sampling
Gastric emptying
at set rate of
material/min

Secretions
Pumped in at set
flowrate

Contractions
Rollers set at
3 contractions/min

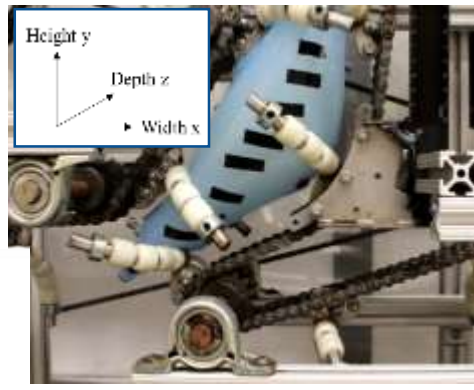
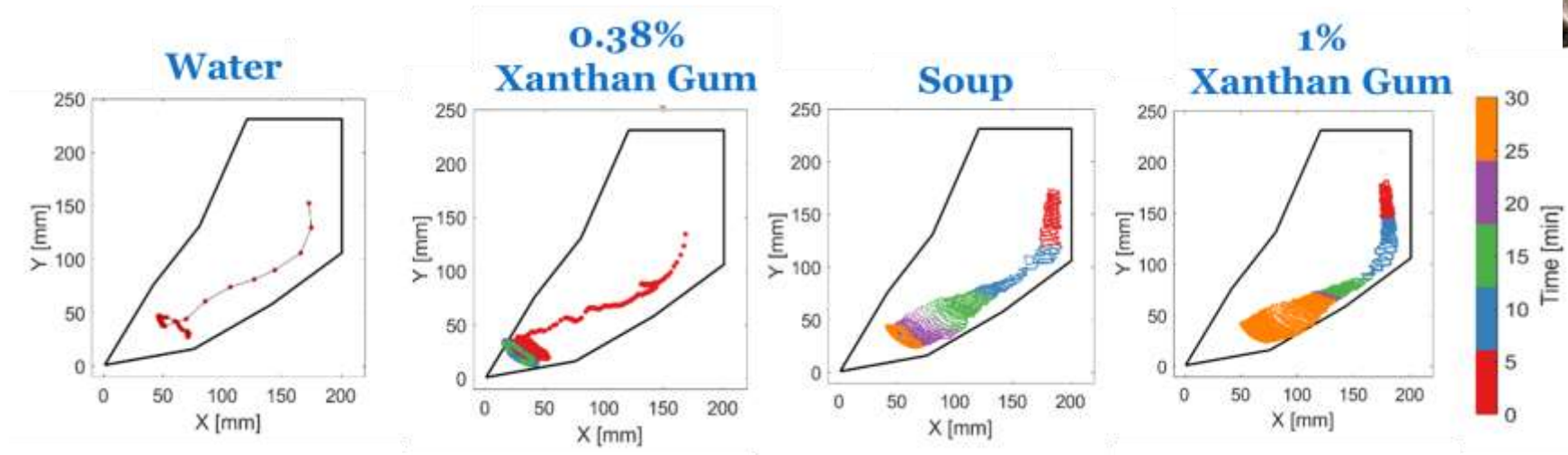
**Temperature
control to 37°C*

Dynamic Model: Human Gastric Simulator v2.0

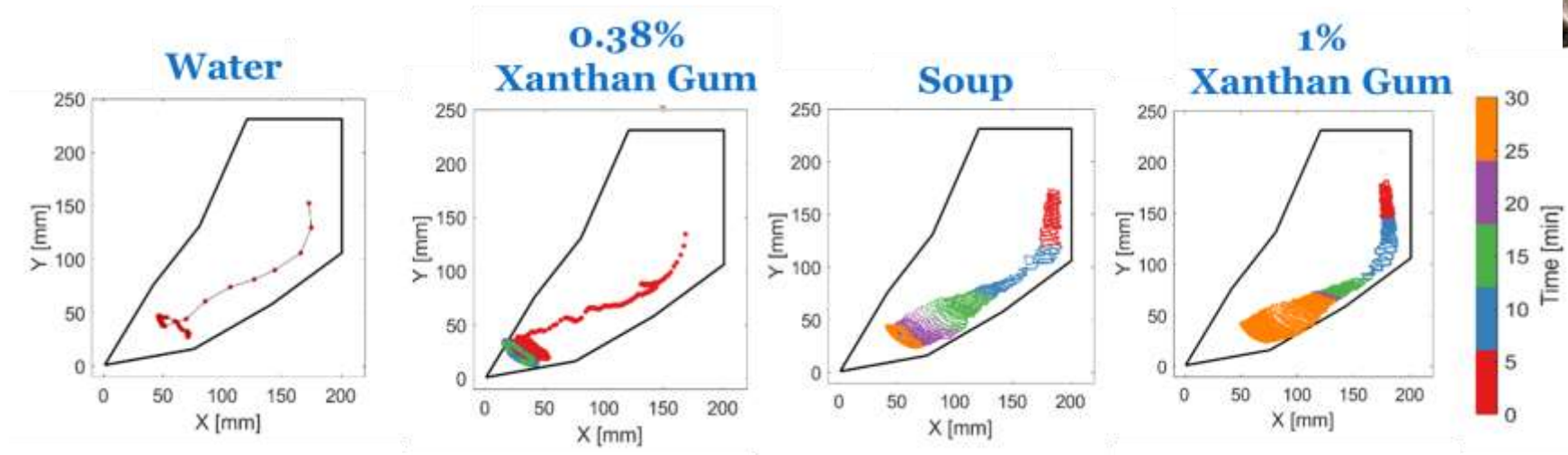
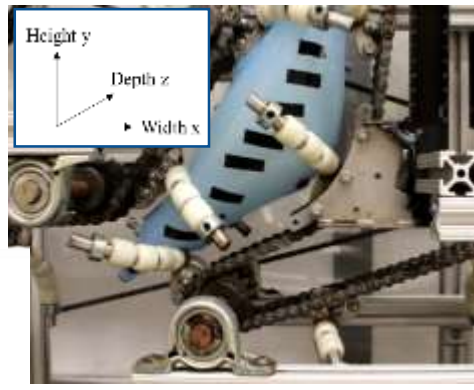


What can be quantified using
this kind of model?

Particle Path through Meals in HGS



Particle Path through Meals in HGS



Average Velocity

220 mm/s

5.5 mm/s

2.4 mm/s

2.2 mm/s

Residence Time

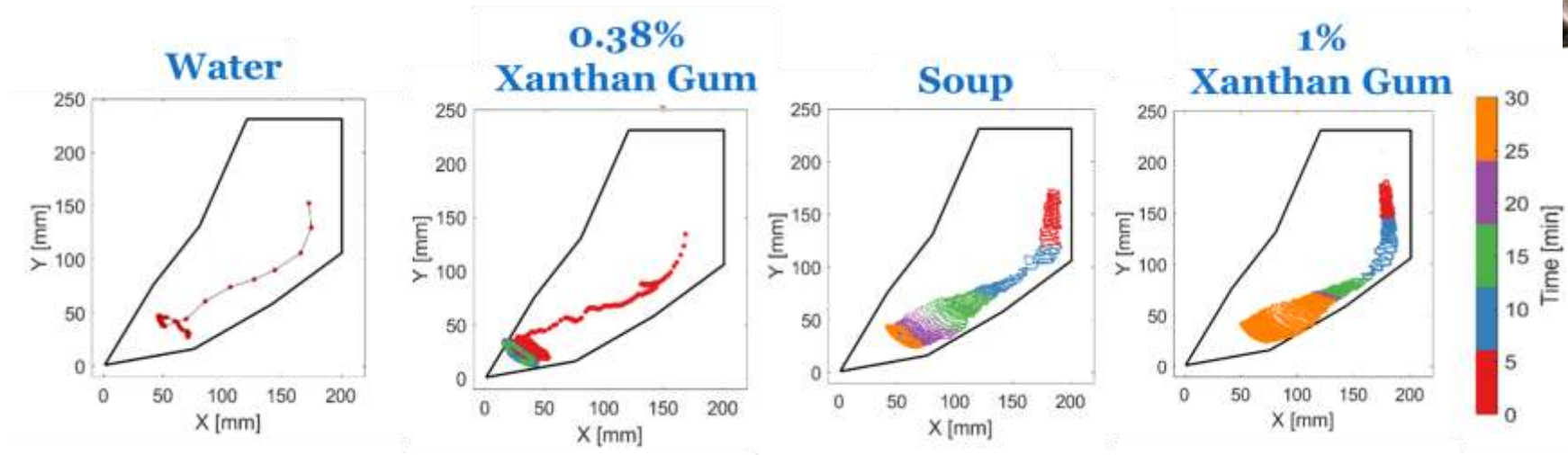
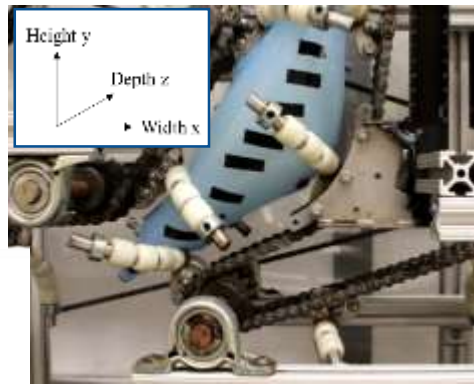
0.013 min

0.6 min

16.4 min

20.4 min

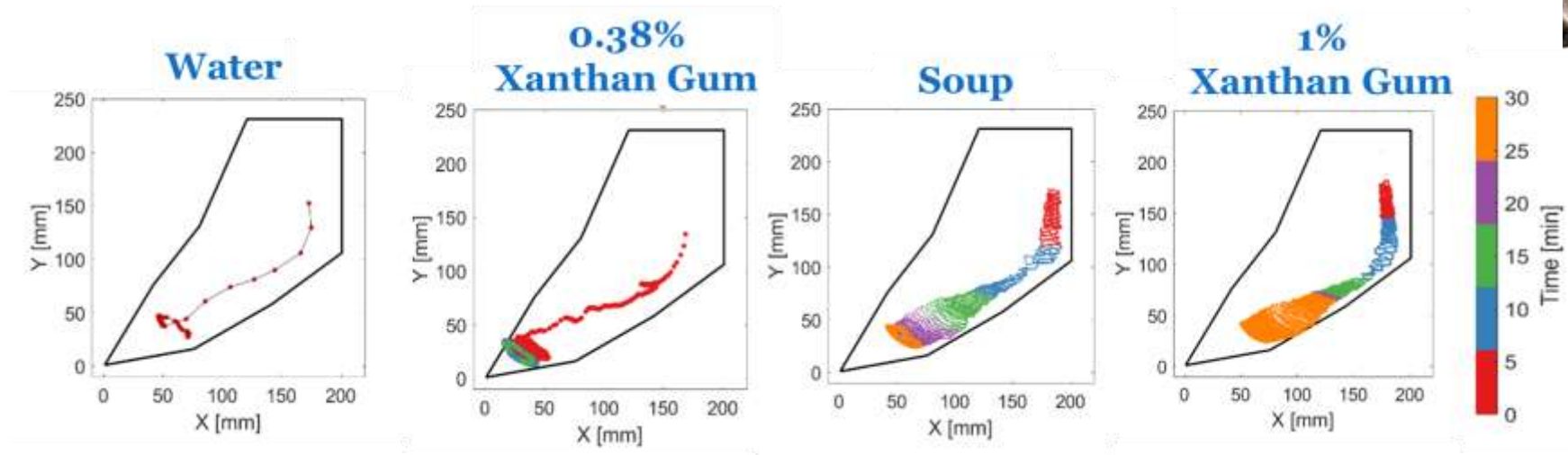
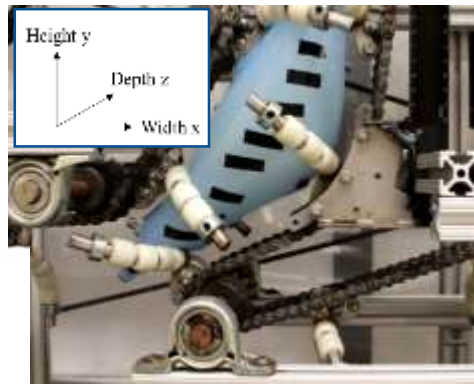
Particle Path through Meals in HGS



Average Velocity	220 mm/s	5.5 mm/s	2.4 mm/s	2.2 mm/s
Residence Time	0.013 min	0.6 min	16.4 min	20.4 min
Consistency Coefficient (K)	0.001 Pa·s ⁿ	1.69 Pa·s ⁿ	6.65 Pa·s ⁿ	10.54 Pa·s ⁿ

Kepler et al. 2020. Journal of Food Engineering. 264: 109674.

Particle Path through Meals in HGS

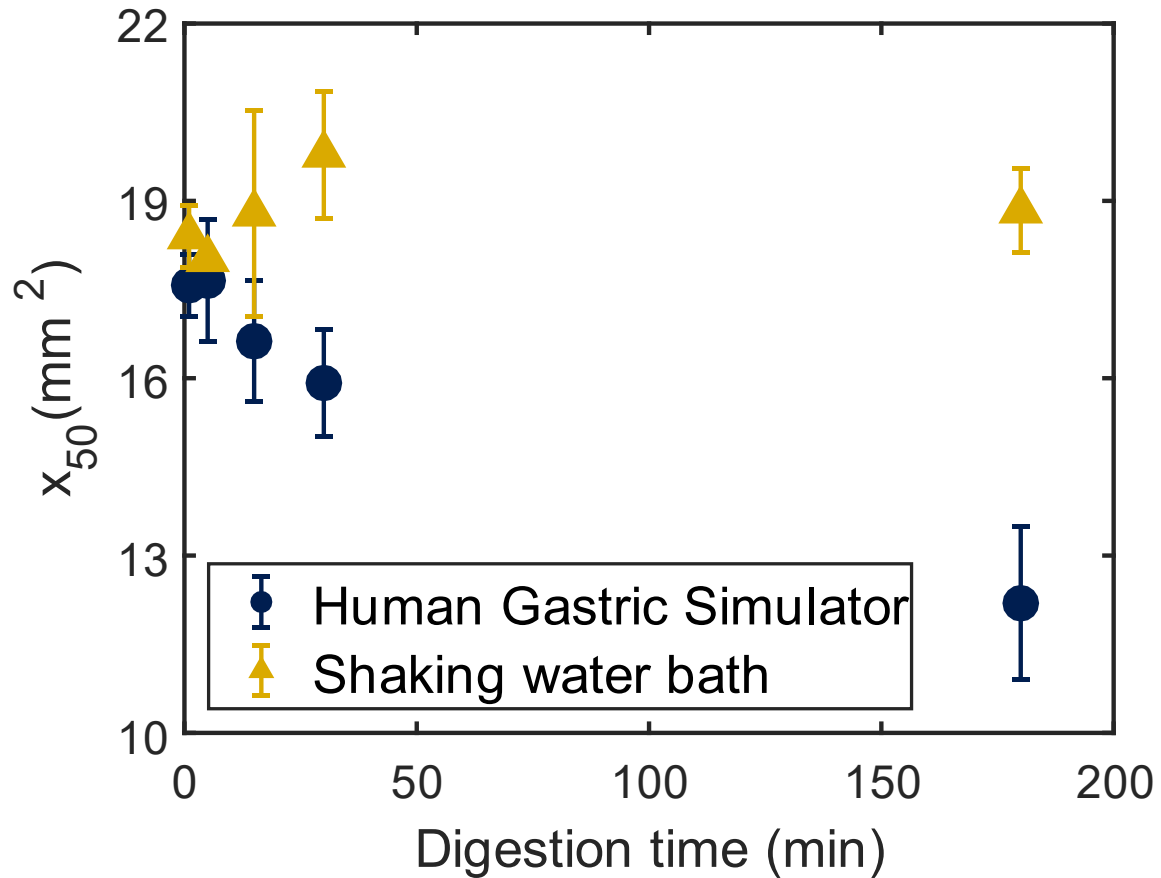


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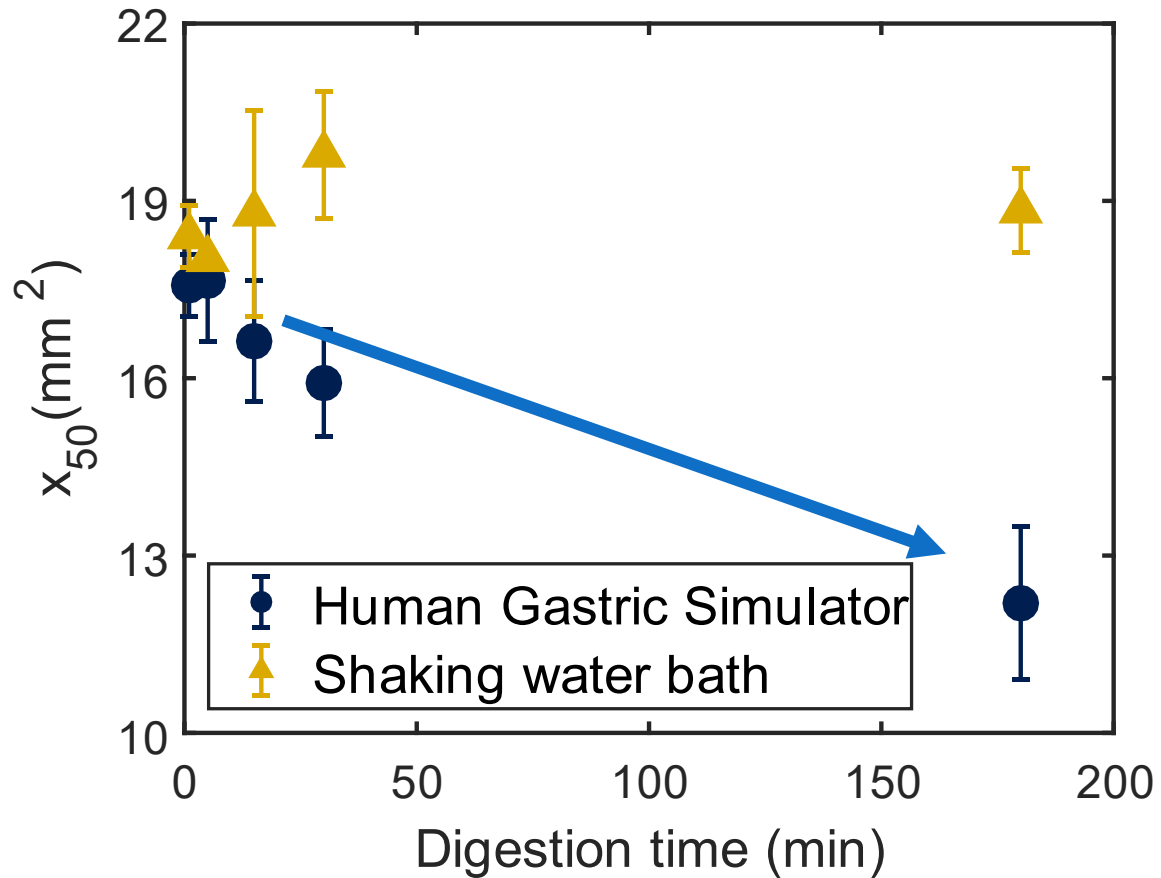
Food Breakdown & Nutrient Release: Almonds

Particle Size Reduction



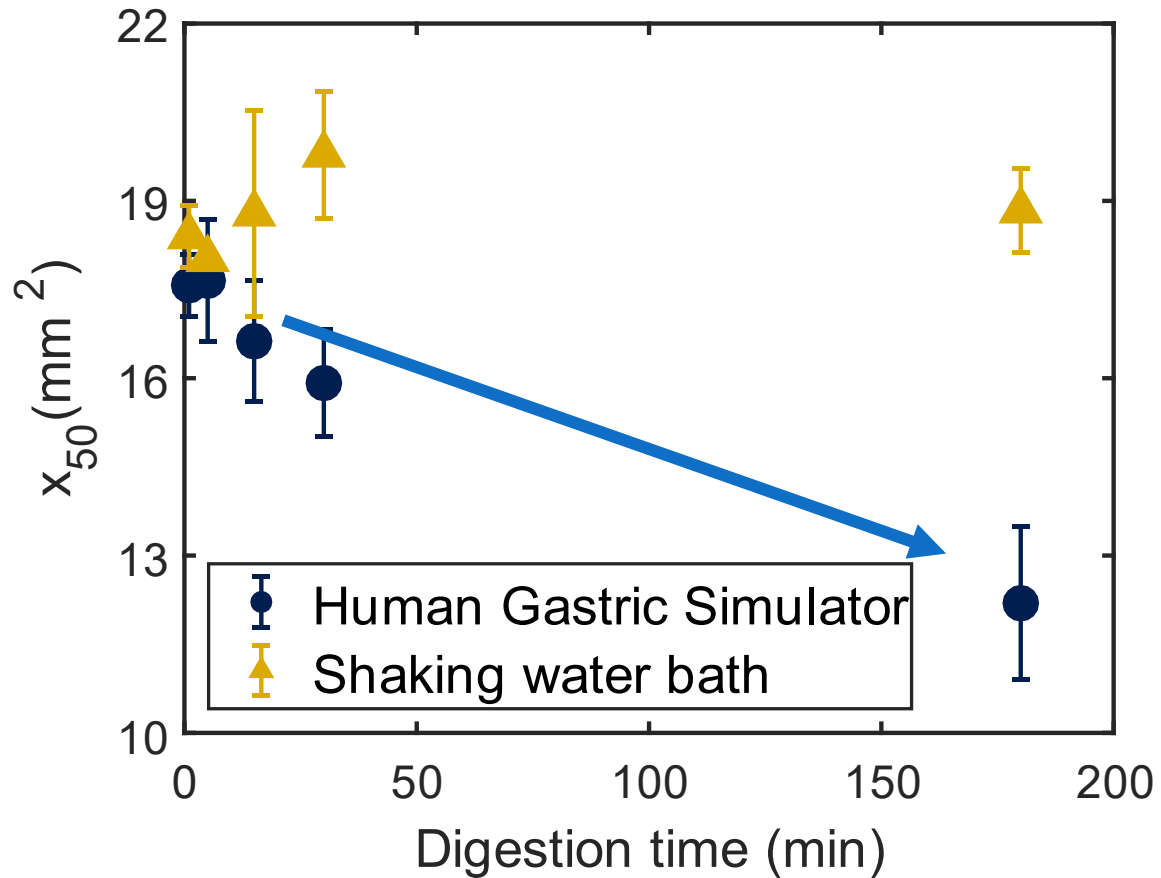
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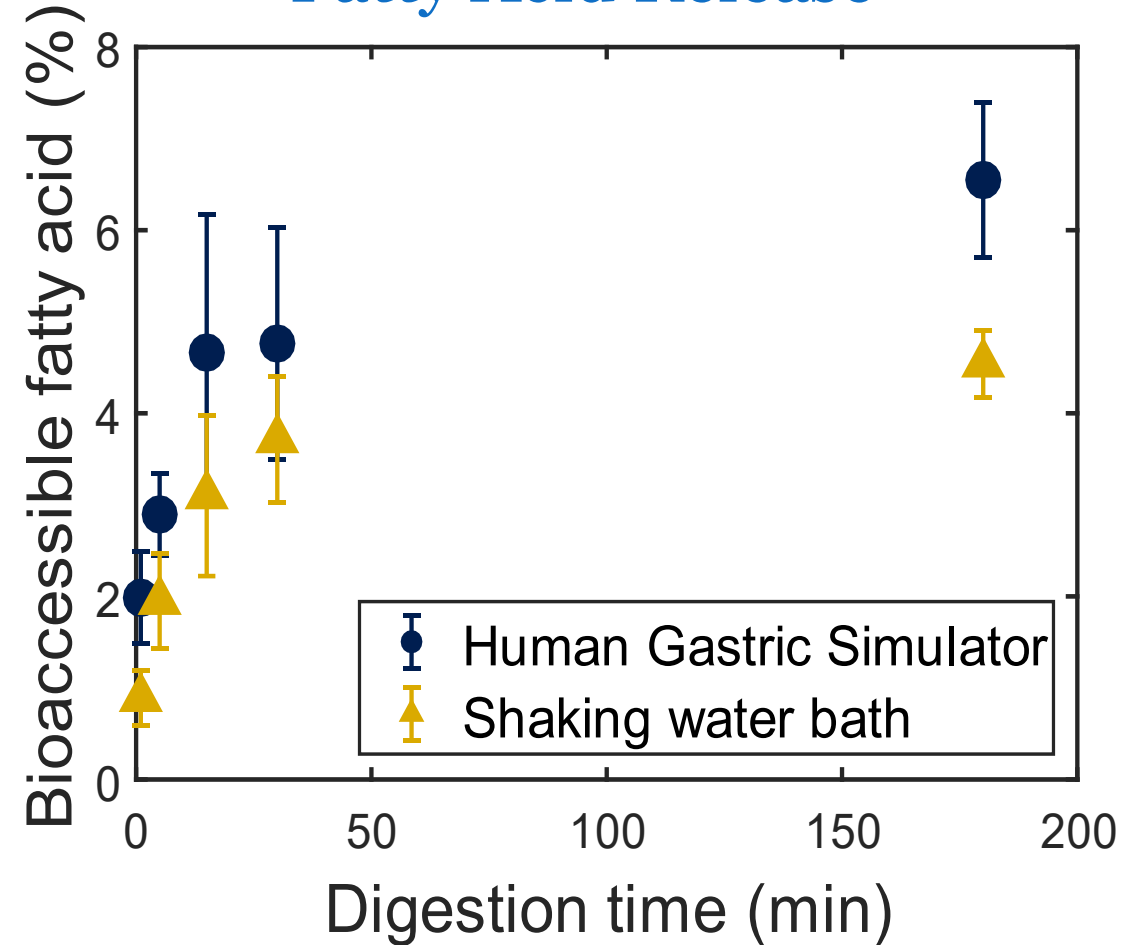


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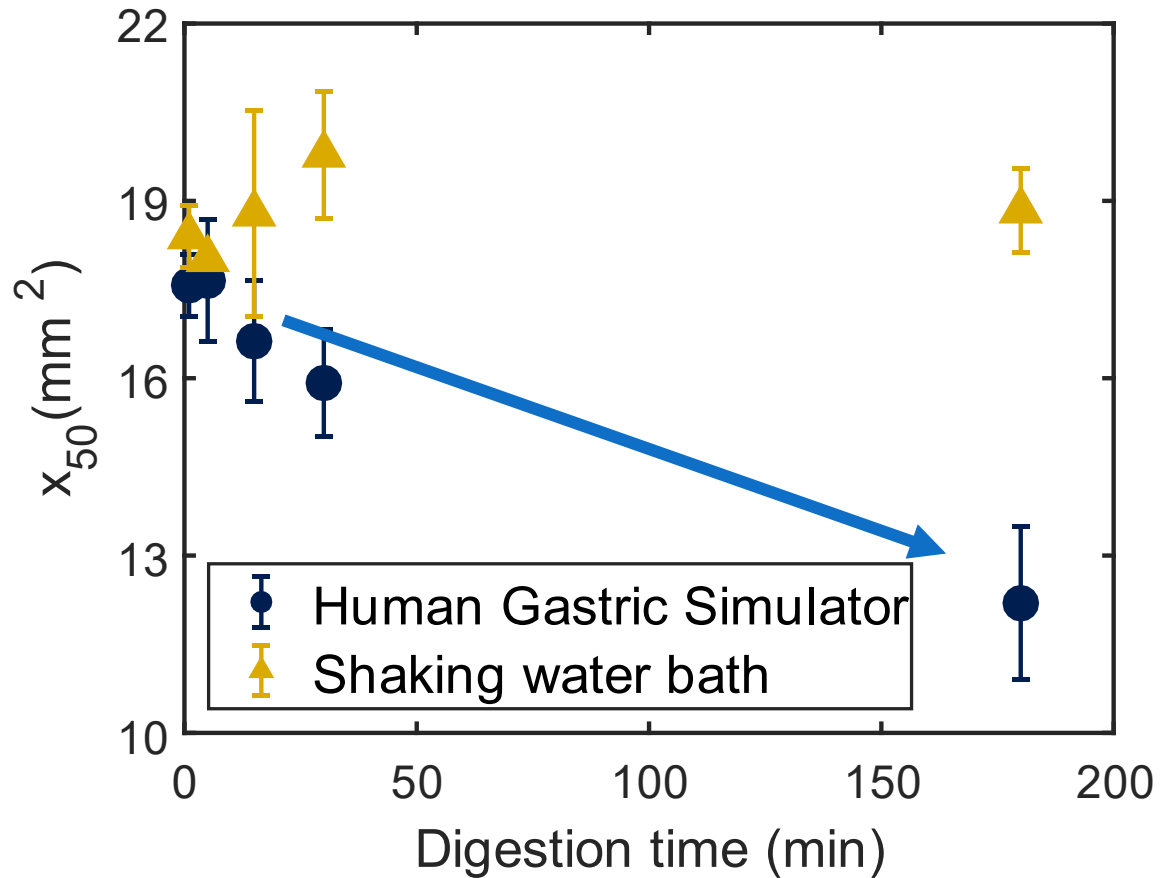


Fatty Acid Release

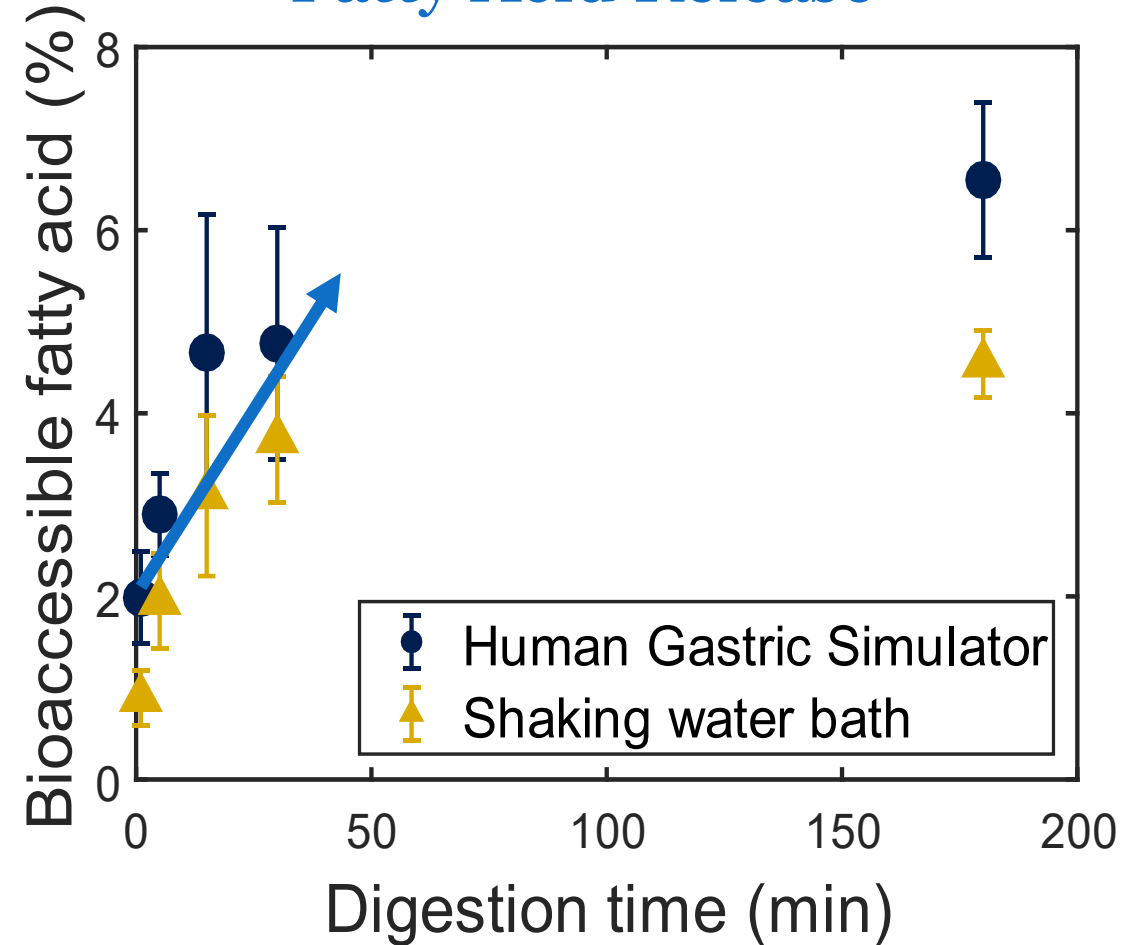


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Fatty Acid Release



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 - Control systems
 - Novel sensors
 - Interactive biomaterials

Summary

- To optimize food functional properties → need understanding of “food digestion plant”
- Many engineering opportunities exist in understanding food digestion to develop in vitro and in silico models
 - Control systems
 - Novel sensors
 - Interactive biomaterials
- Advanced in vitro models can be used to understand parts of the digestion process
 - Particle movement
 - Breakdown
 - Nutrient release

Acknowledgements

UCDAVIS
BIOLOGICAL AND AGRICULTURAL
ENGINEERING

UCDAVIS
FOOD SCIENCE AND
TECHNOLOGY

 **Riddet
Institute**
FOOD | INNOVATION | HEALTH



**Thanks for
your
attention**

