FERRUH ERDOGDU

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CFΠ-COMPUTATIONAL FOOD PROCESSING GROUP

Sustainable Novel Approaches for Food Processing in the view of Food Safety

Food Safety

Food safety: an assurance that food will not cause harm

Food borne cases: 66M cases – 420K deaths per year (WHO, 2023)

Allergens – foreign matter – processing contaminants - failed process – process design issues

Salmonella – *Listeria* - *E. coli* O157:H7 – recent *Cronobacter sakazakii* cases

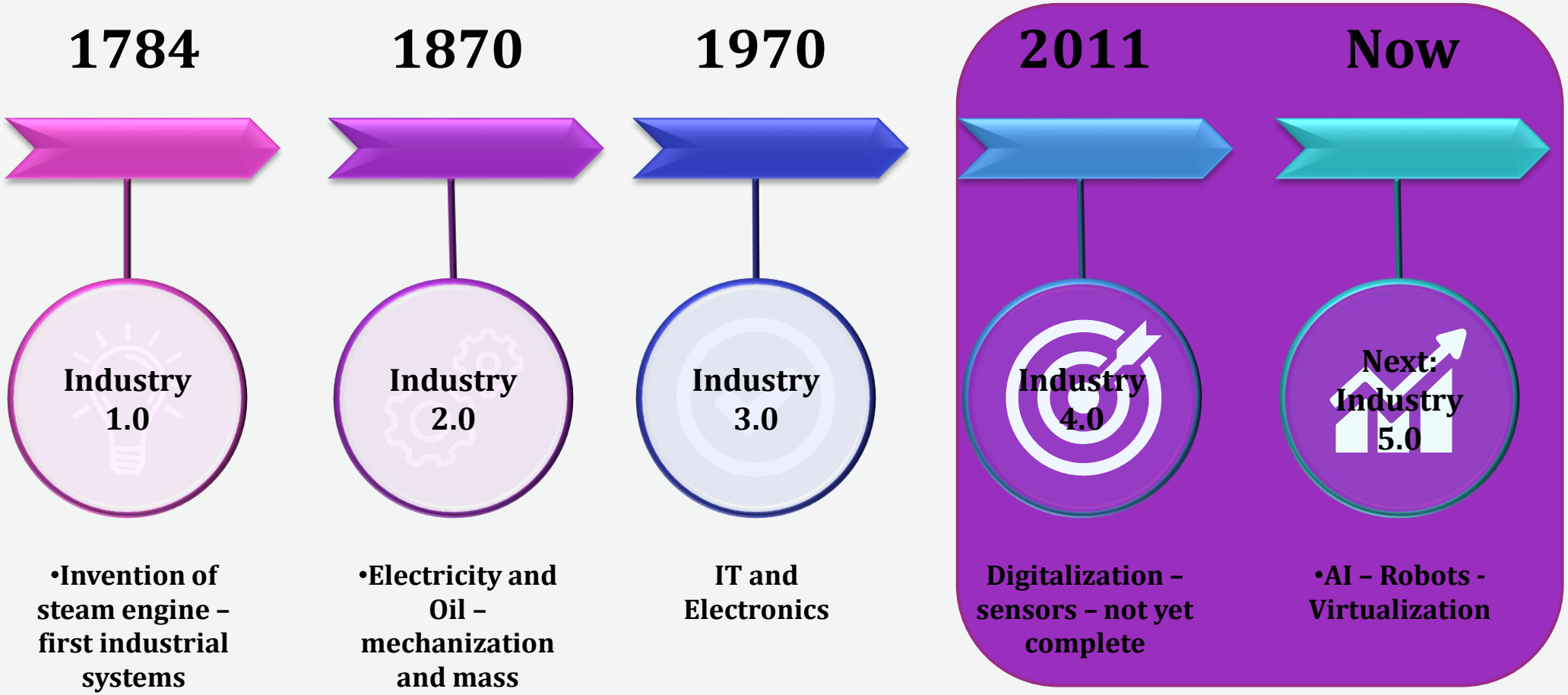
FOOD INDUSTRY: 4.0 -5.0 –X.0…

MORE DEMANDING

INNOVATIVE – NOVEL – SUSTAINABLE FOR SAFETY AND QUALITY!

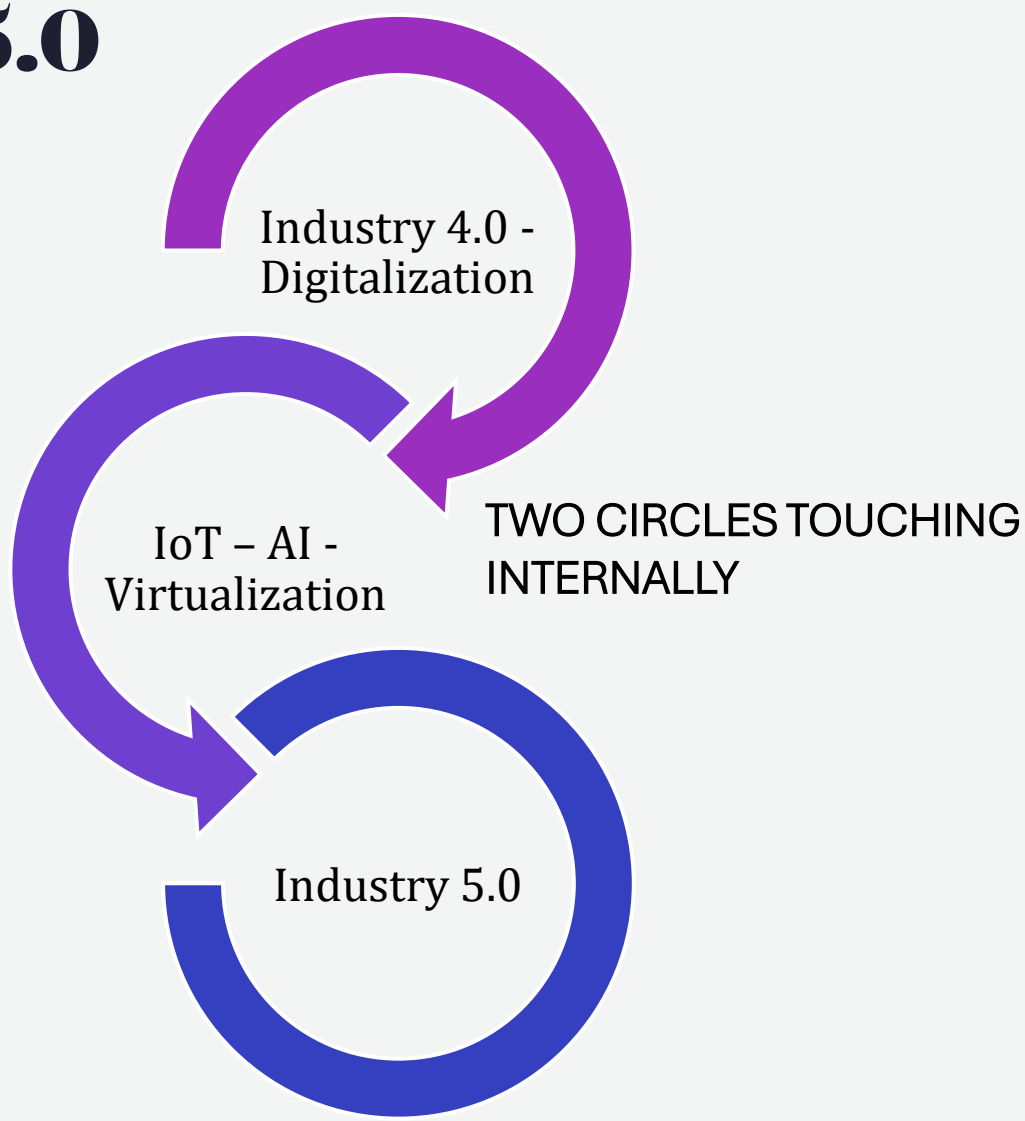
INDUSTRY

TWO CIRCLES TOUCHING INTERNALLY



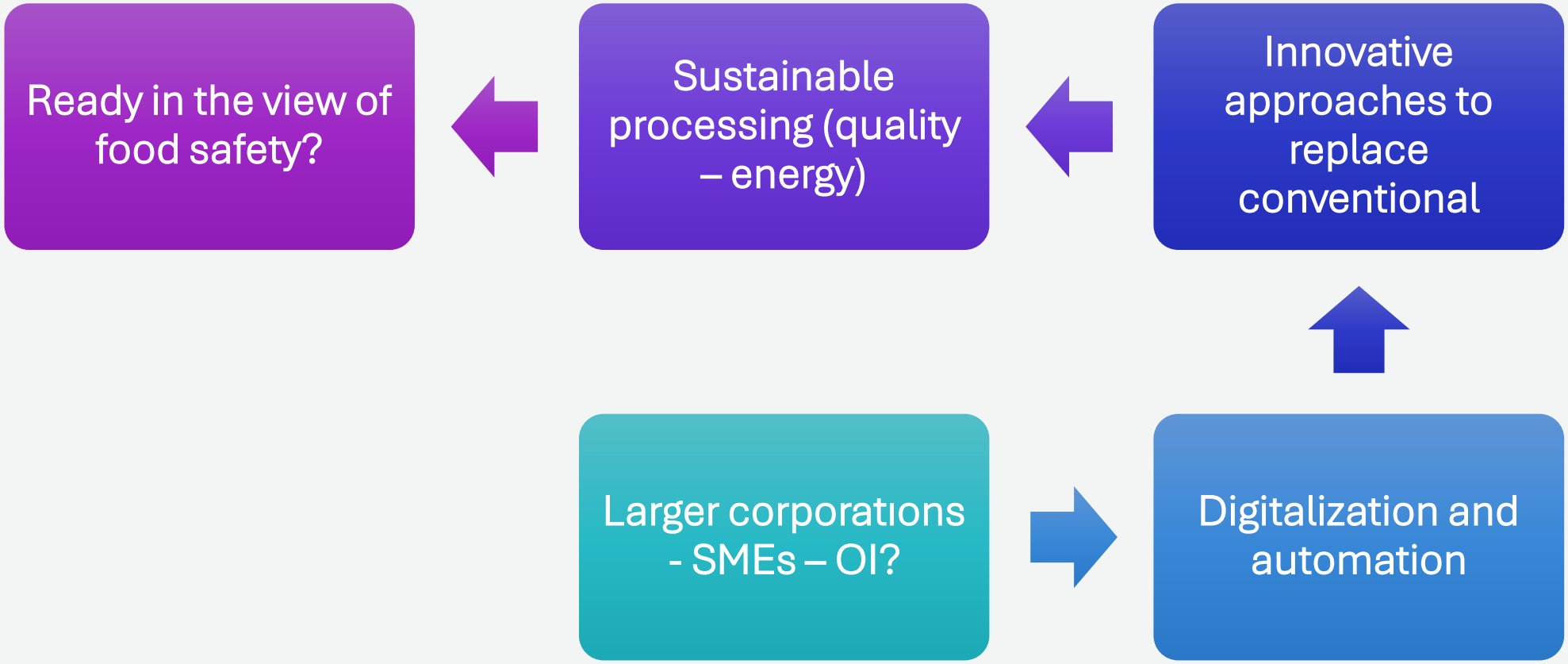
Bigliardi, 2021.

Industry 4.0 – 5.0



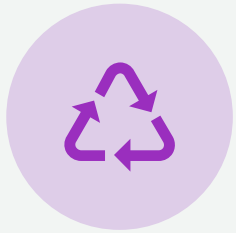
TWO CIRCLES TOUCHING INTERNALLY

Challenges


Ready in the view of food safety?
Sustainable processing (quality – energy)
Innovative approaches to replace conventional
Larger corporations - SMEs – OI?
Digitalization and automation

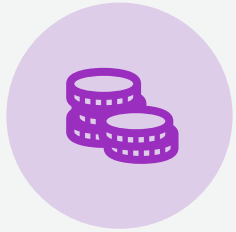
Sustainable food processing

ENVIRONMENTAL-FRIENDLY



NON-POLLUTING

CARBON AND WATER FOOTPRINT?



ECONOMICALLY EFFICIENT

OVERCOME ISSUES IN CONVENTIONAL PROCESSING

Food Processing

European Green Deal

FAO – WHO: `Food Safety: Prepare for the Unexpected`

DESIGN AND OPTIMIZATION!

CONTROL OF THE PROCESSING CONDITIONS

PREDICT THE PROCESS OUTCOMES

IMPROVED SAFETY – QUALITY!

Food safety issues

"Food safety: Prepare for the unexpected"

Salmonella in onions – tahini – peanut butter

a_w<0.85

Salmonella in hummus - eggs – chocolate products- pea protein cases

Listeria in ice-creams – nuts – smoked salmon – white cheese

Cronobacter sakazakii in infant formulas

a_w<0.85

A proper (THERMAL) processing is expected by the industry!

Sustainable processes

Optimized processing – scale-up!

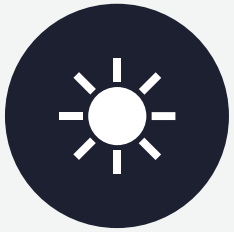
MICROWAVE – RADIO FREQUENCY

INFRARED

OHMIC HEATING

INDUCTION

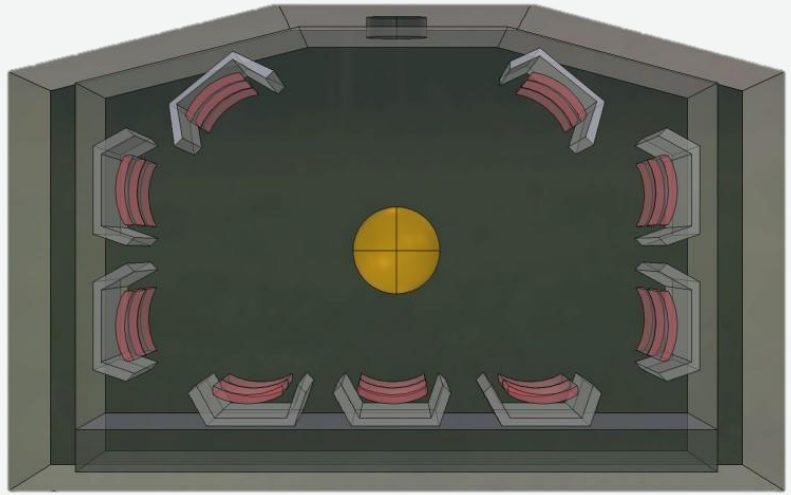
ULTRASOUND

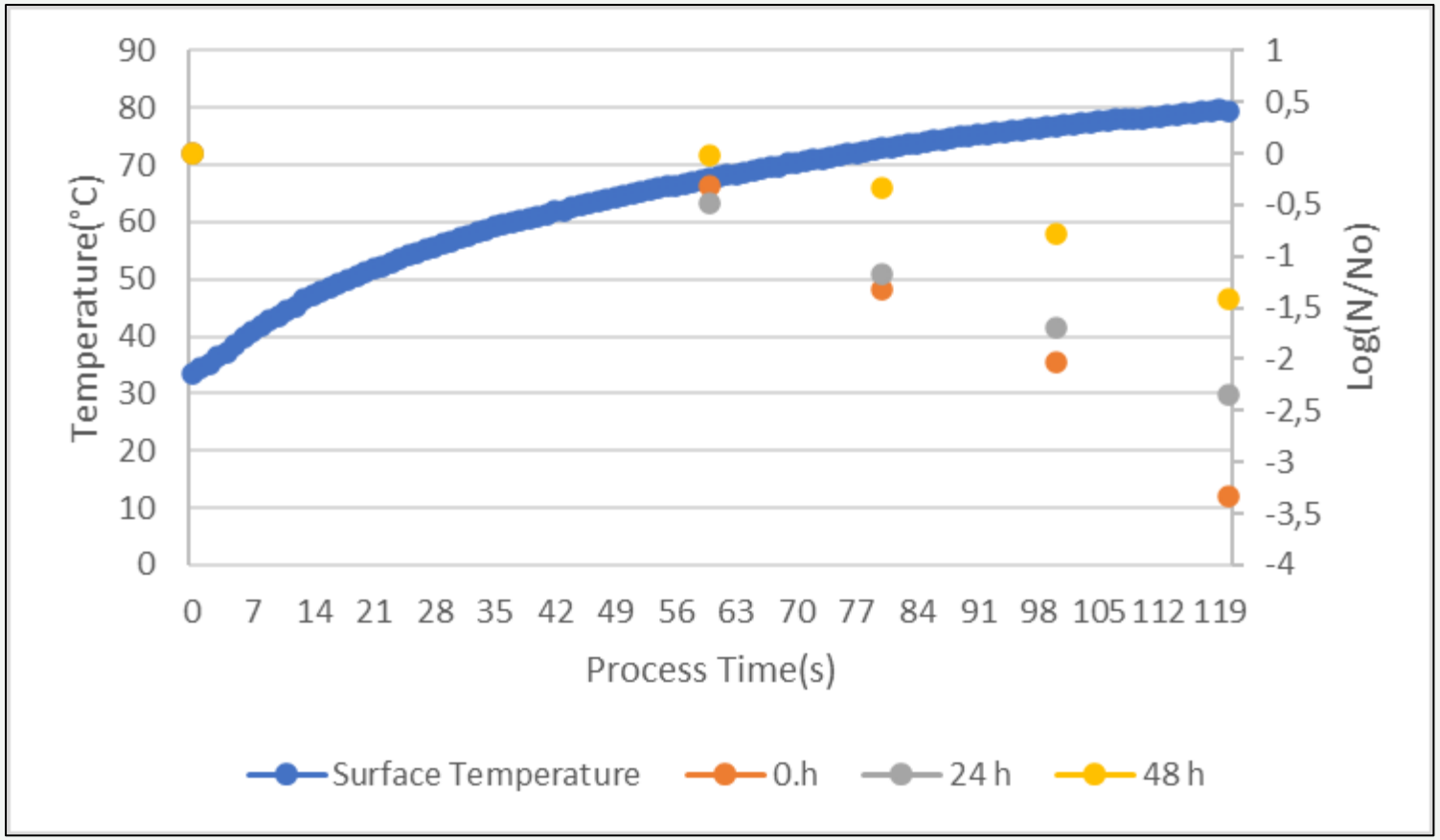


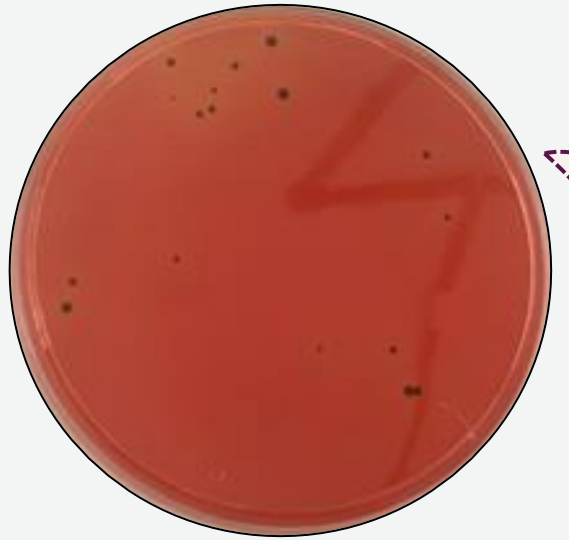
PEF – HIGH PRESSURE - UV

Dry onions – Microwave Processing

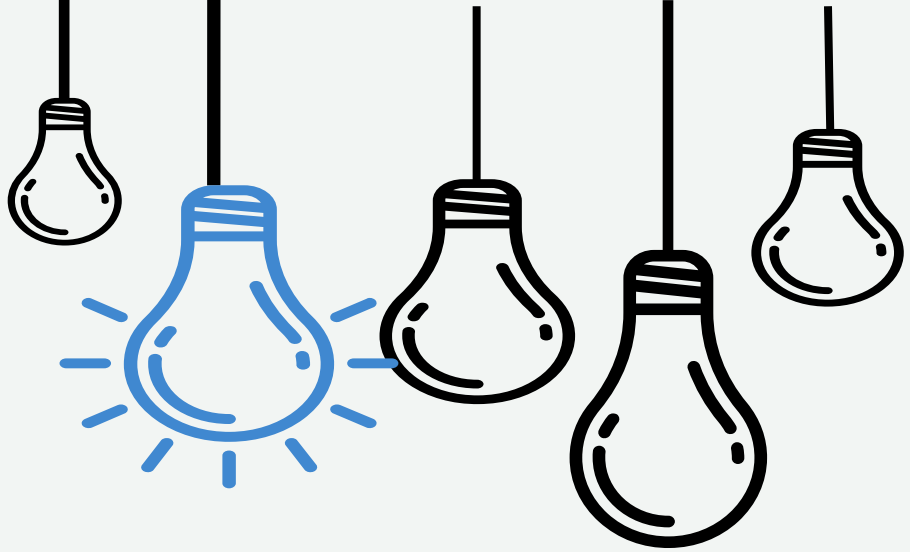
October 2020 – *Salmonella* Newport – issue still has continued!

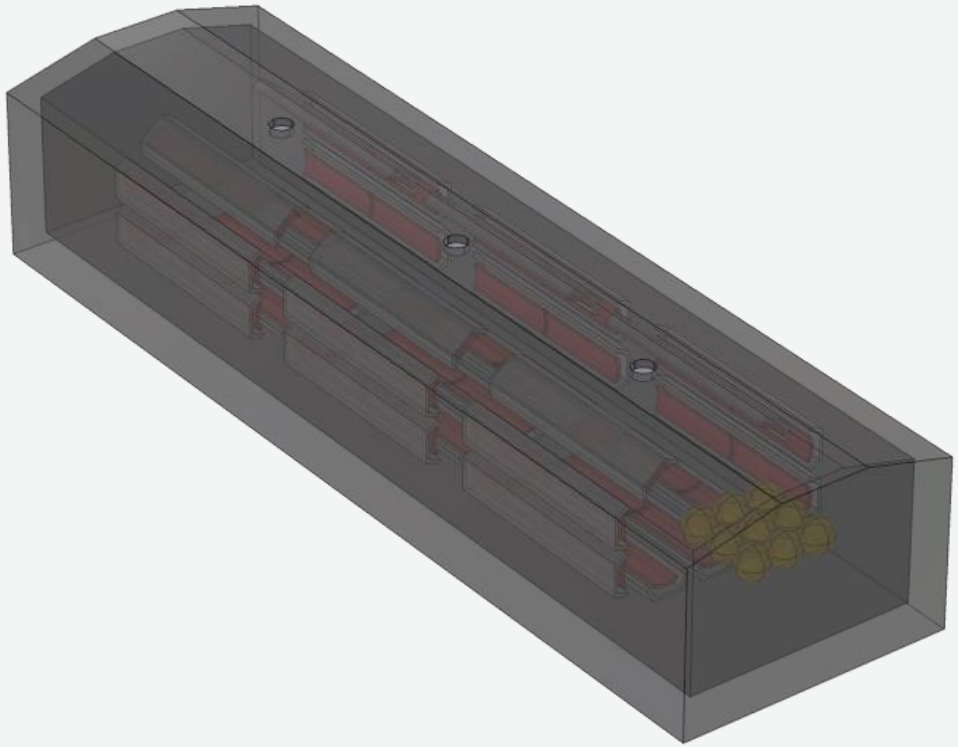



90
80
70
60
50
40
30
20
10
0
Temperature(°C)
1
0,5
0
-0,5
-1
-1,5
-2
-2,5
-3
-3,5
-4
Log(N/No)
0 7 14 21 28 35 42 49 56 63 70 77 84 91 98 105 112 119
Process Time(s)
Surface Temperature
0.h
24 h
48 h



3.5 log



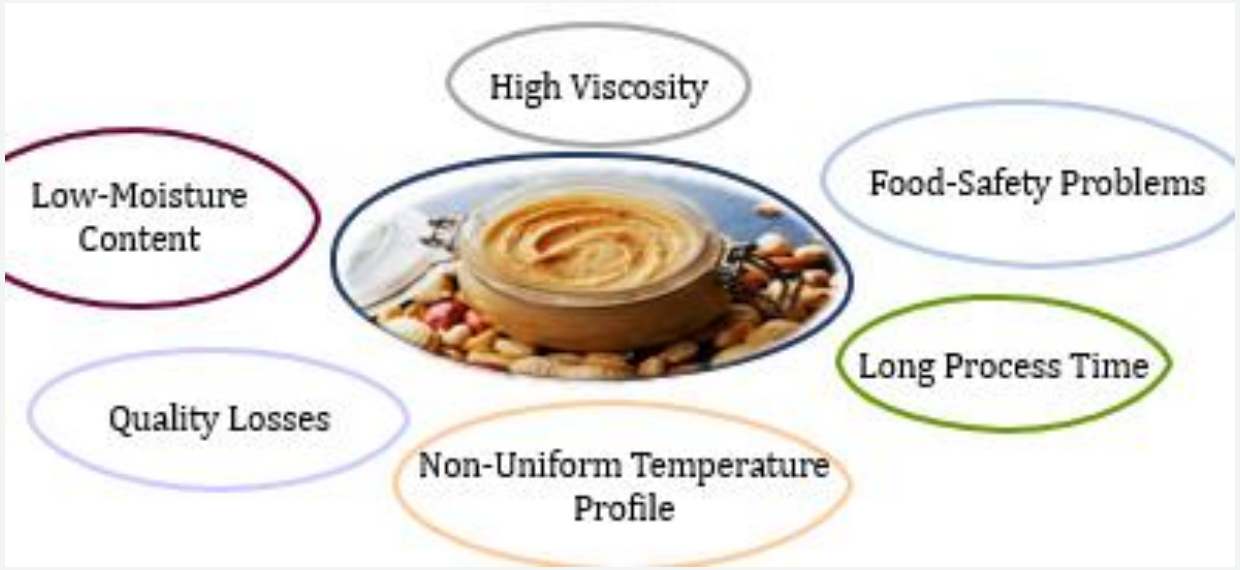


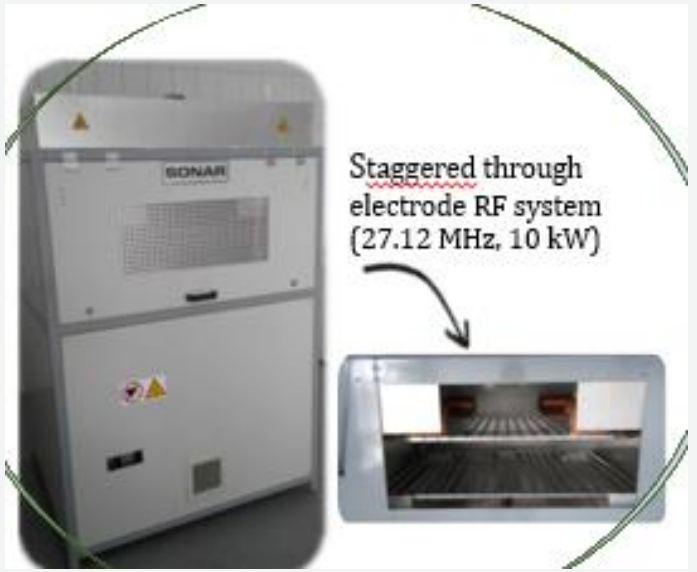
120 s process;

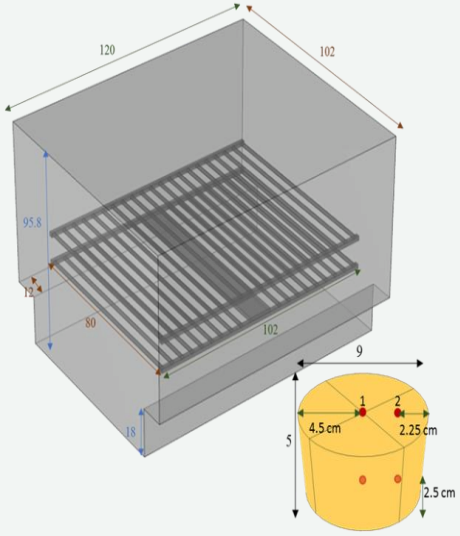
- ✓ Surface temperature→ 80°C
- ✓ 3.3 $\log_{10}$ CFU/cm^2
- ✓ Hexagon cavity- 3 onion – moving mesh→ OPTIMUM
- ✓ **≈100 kg / 1h capacity**

Peanut Butter – Radio Frequency Processing

***Salmonella* – since 2012!**

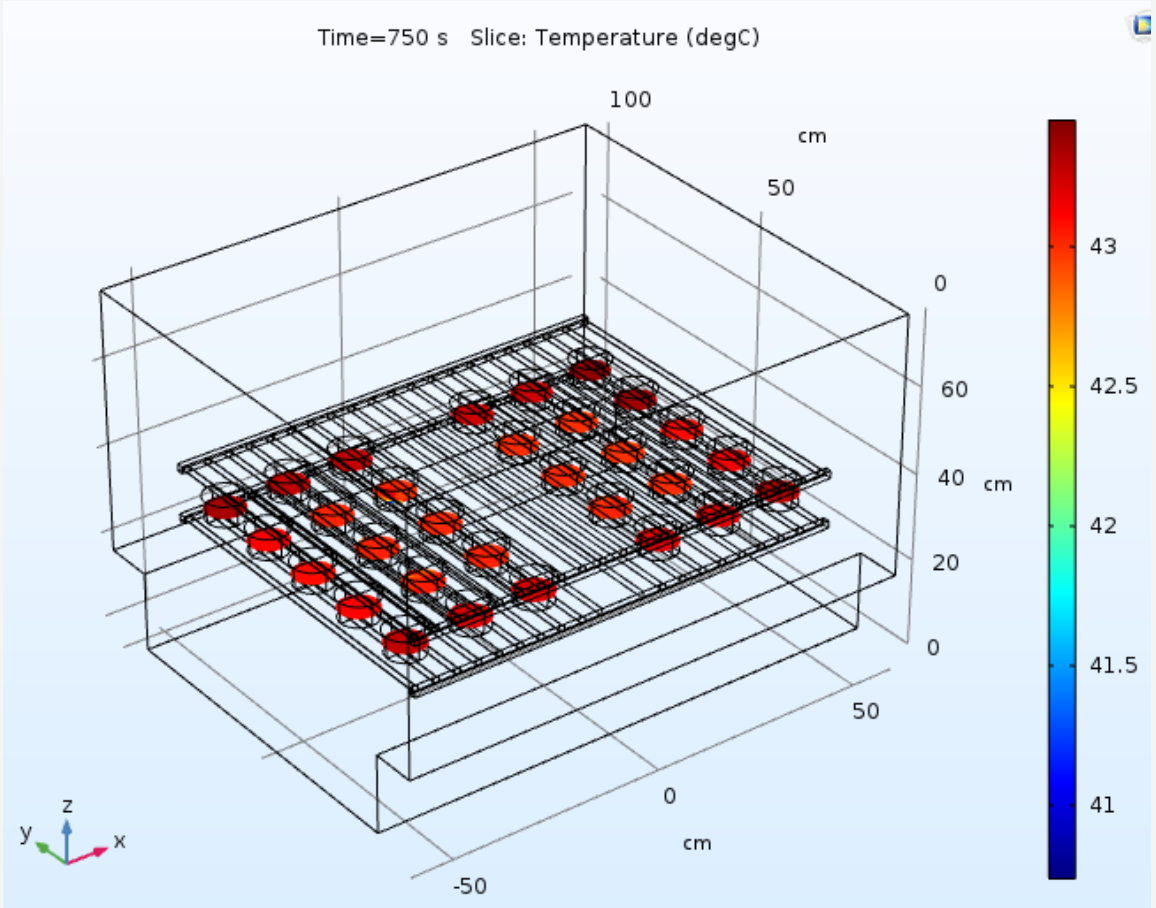






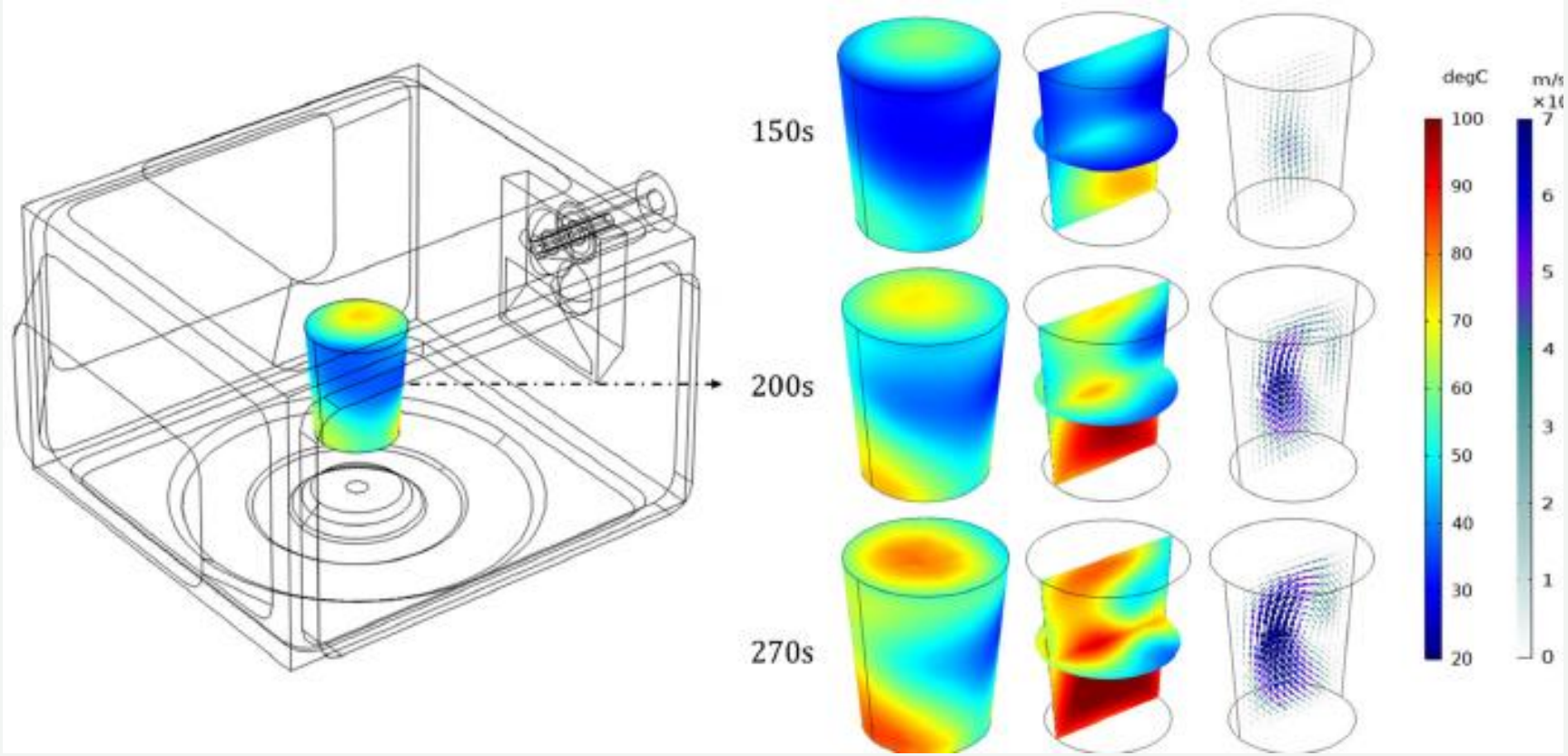
Industrial Scale Simulations

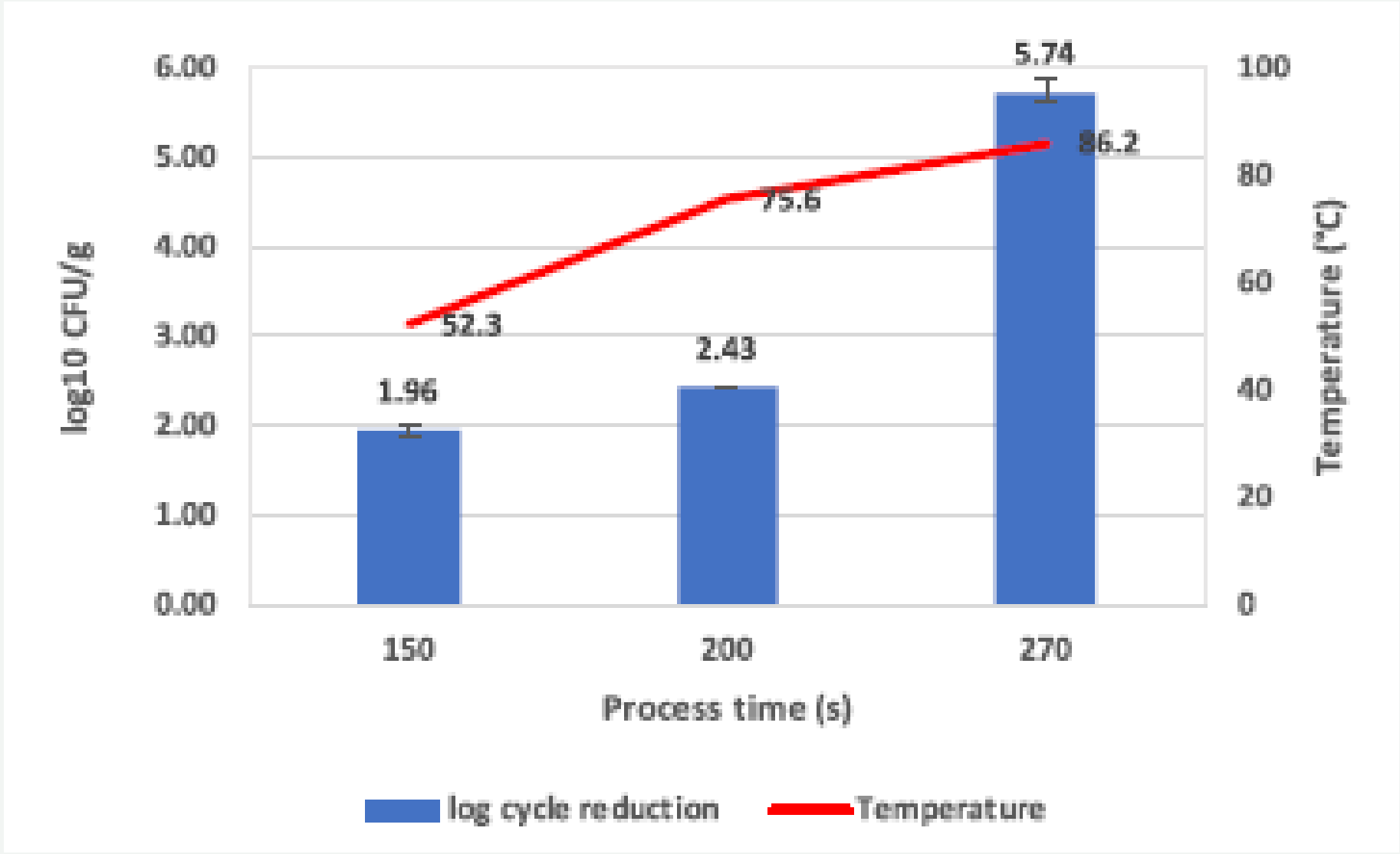
4000 V potential



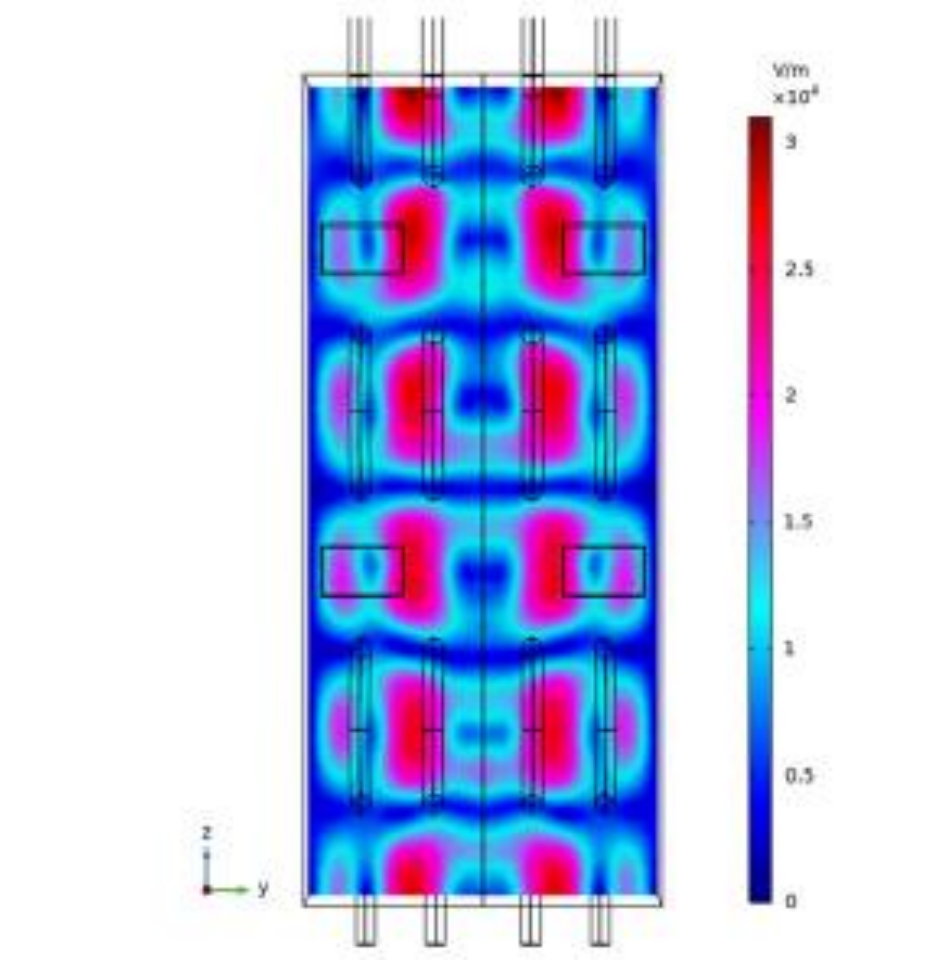
Tahini – Microwave Processing

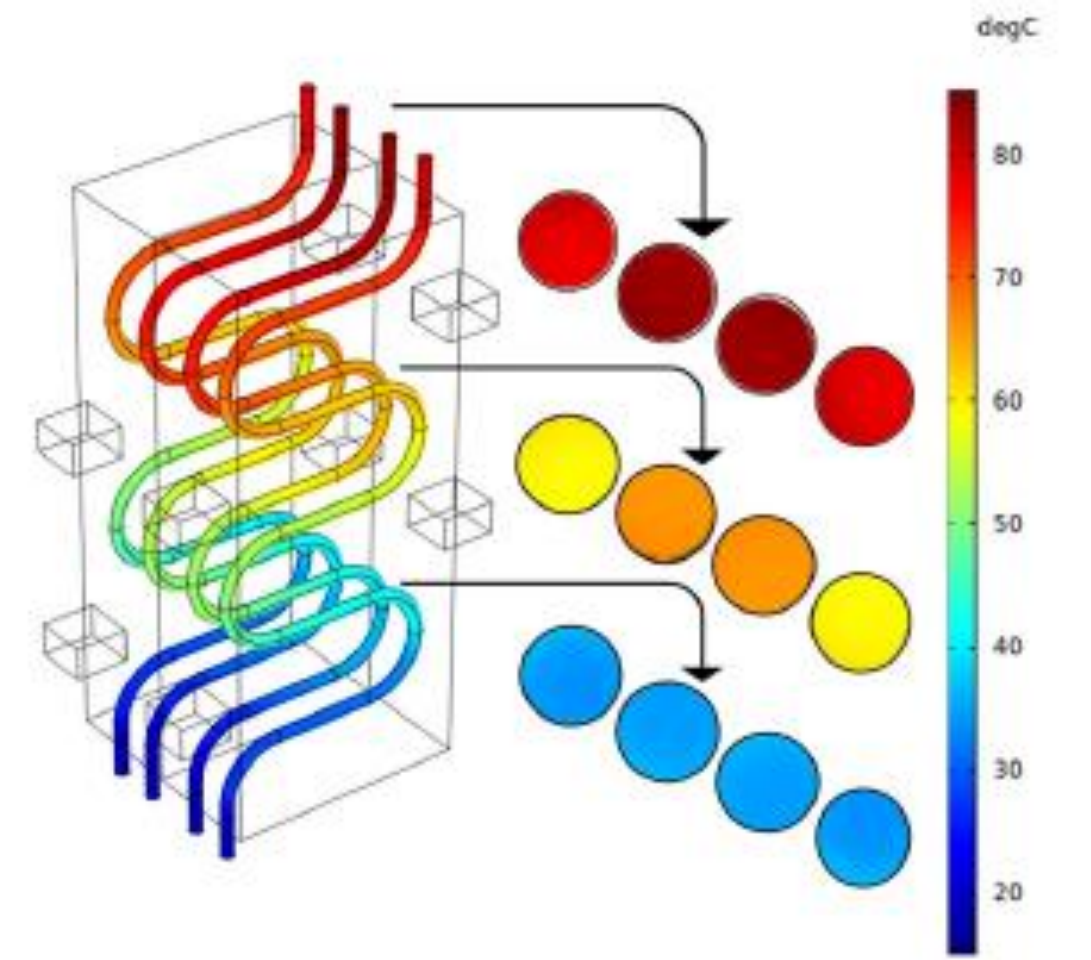
Salmonella – sesame source (roasting!) in the last 2-decades!



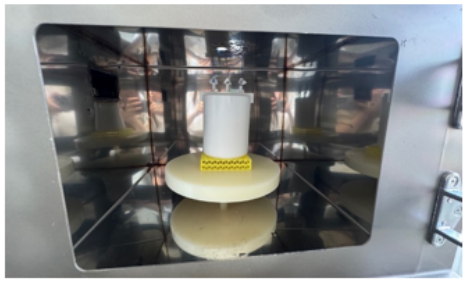

6.00
5.00
4.00
3.00
2.00
1.00
0.00
log10 CFU/g
100
80
60
40
20
0
Temperature (°C)
1.96
2.43
5.74
52.3
75.6
86.2
150
200
270
Process time (s)
log cycle reduction
Temperature

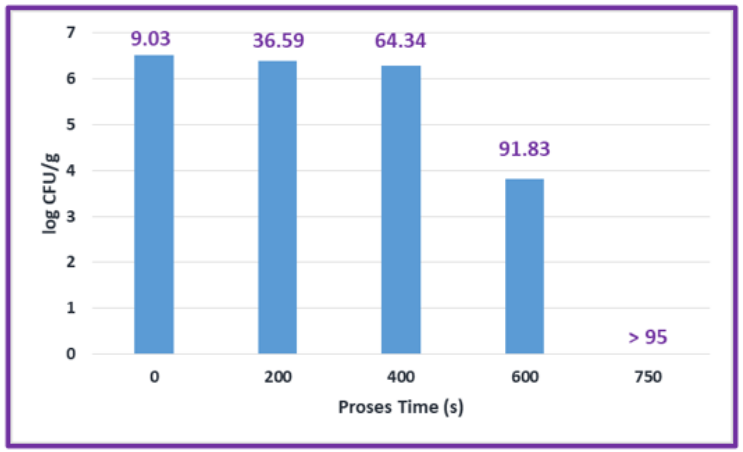
Industrial Scale Simulations

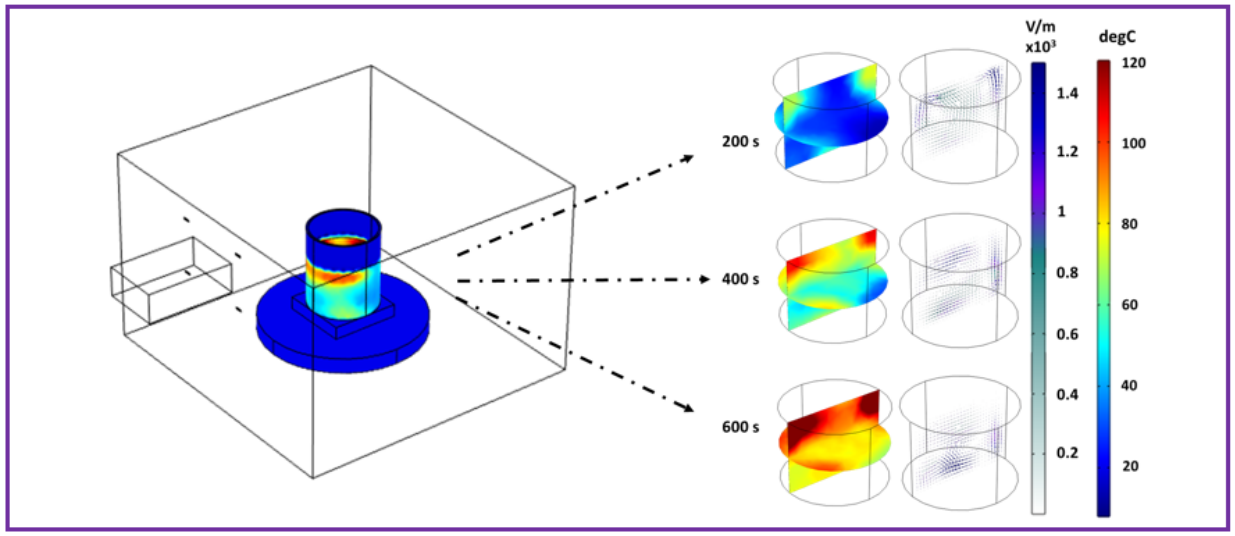


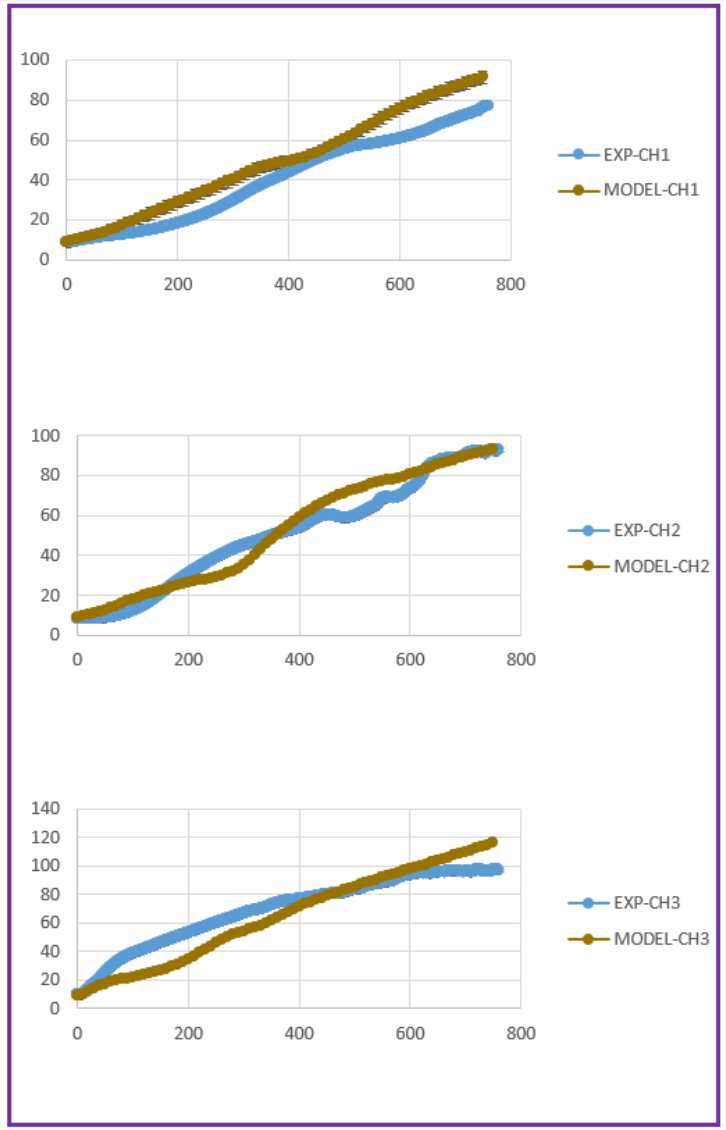


Ice cream mix – Microwave Processing *Listeria* recalls!









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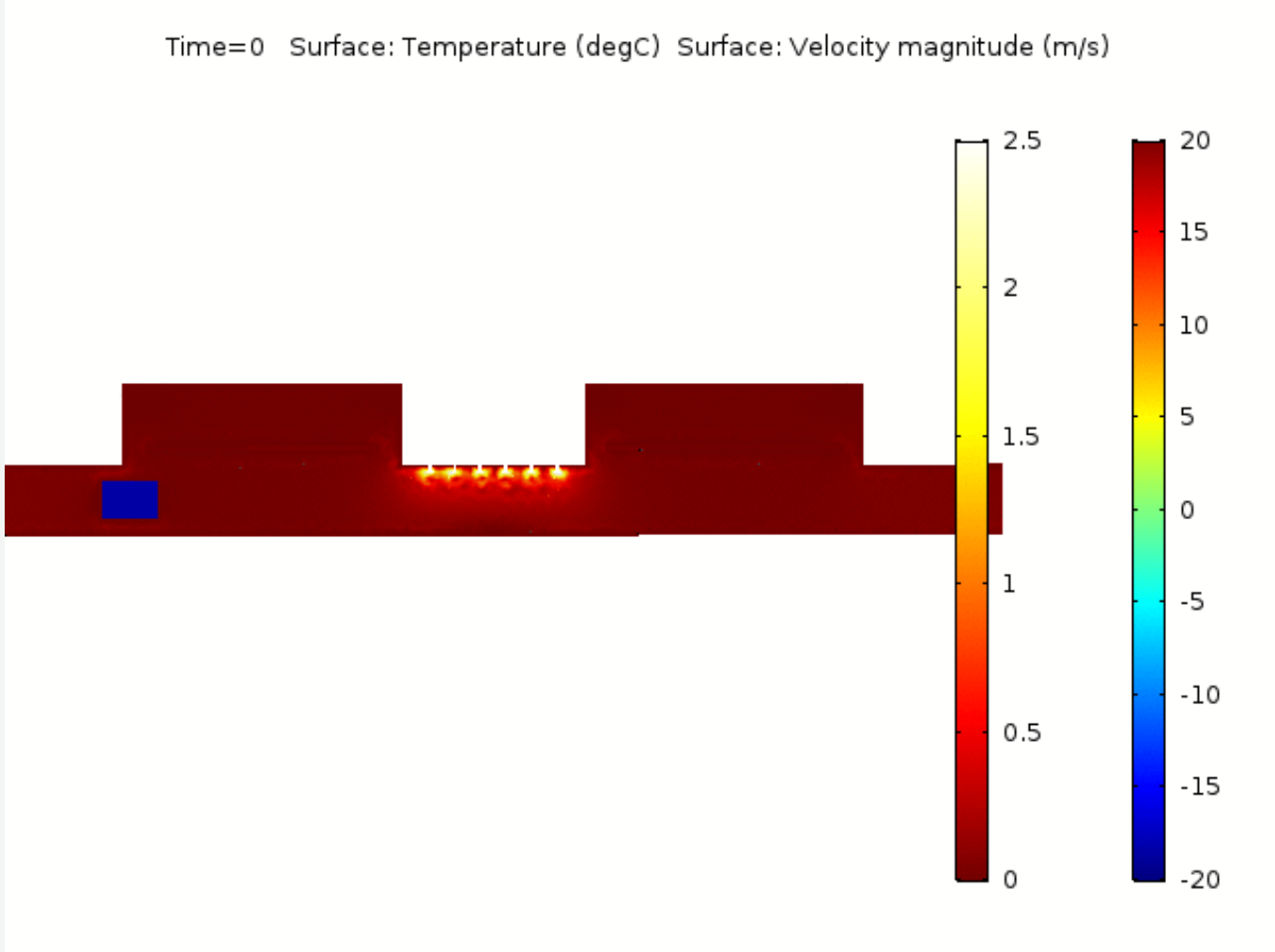


- Hummus – microwave processing
- Butter milk – microwave processing
- Infant formula – radio frequency processing
- Microbiological quality in industrial thawing – radio frequency processing

Future of the Food Manufacturing for improved safety and quality

For process innovation:

Digital twin concept

Virtualization

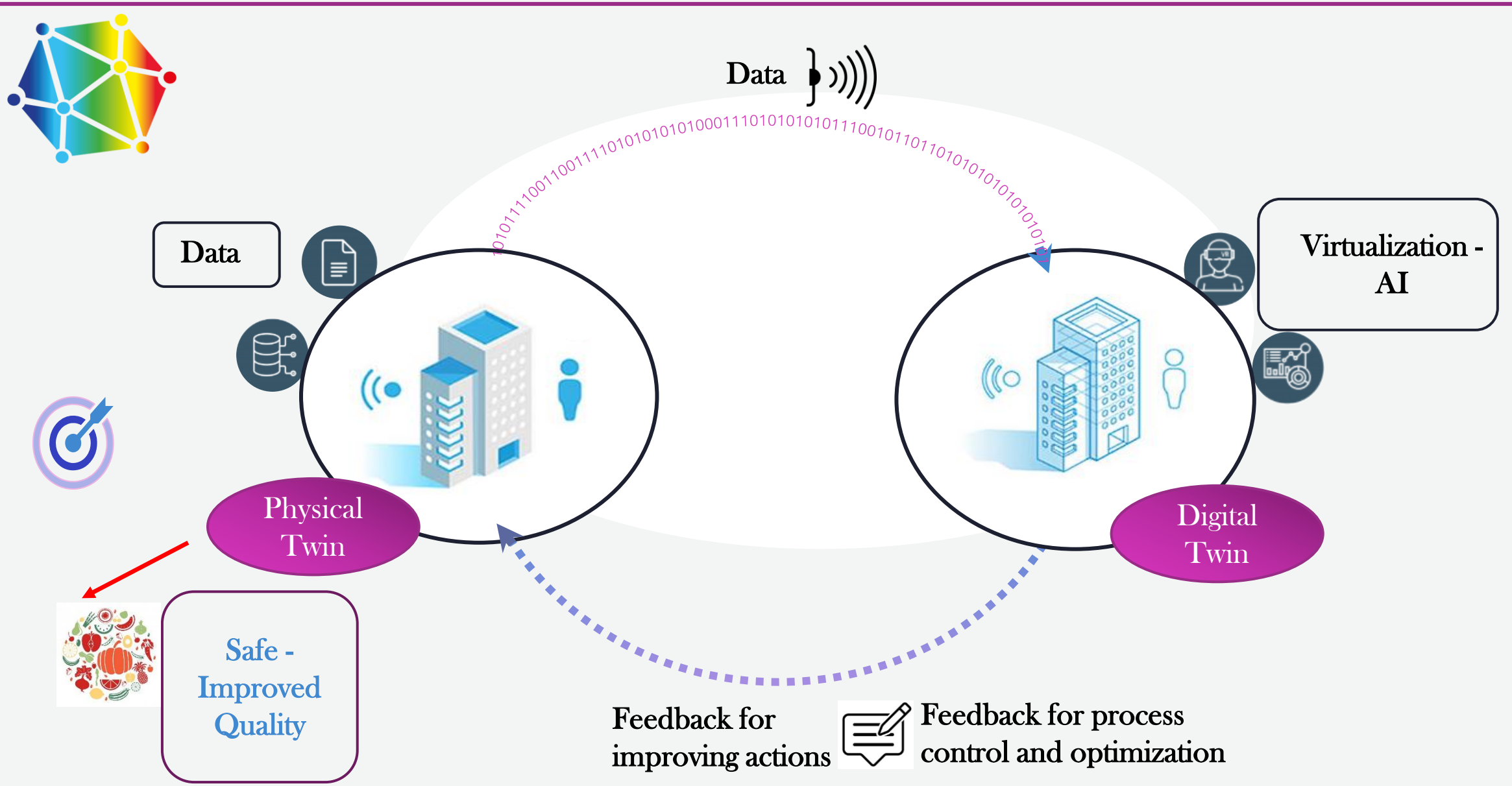
AI – Internet of Things (IoT)

Sustainability – dynamic analysis

Digital twin

Incorporating the modelling into actual process – simulation – virtualization

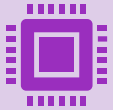
Online incorporation to use big data and enable the required changes – make corrective actions during operation for optimized process


Data
Data
Virtualization - AI
Physical Twin
Digital Twin
Safe - Improved Quality
Feedback for improving actions
Feedback for process control and optimization

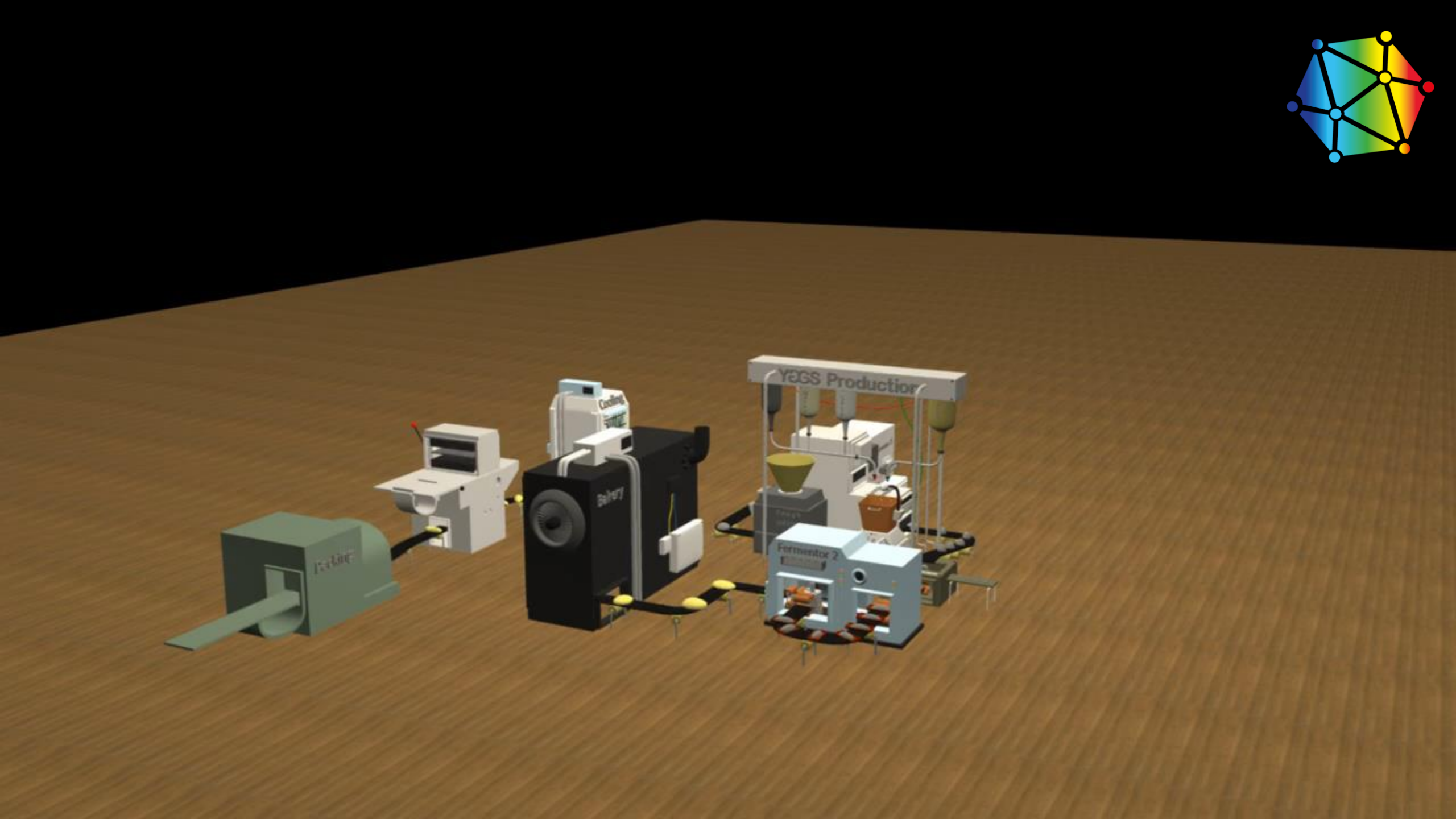
Conclusions

Electro-heating technologies – possible solution for (microbial) process safety in the view of sustainability and upcoming Green Deal!

Process control with virtualization and scale-up is a significant issue!

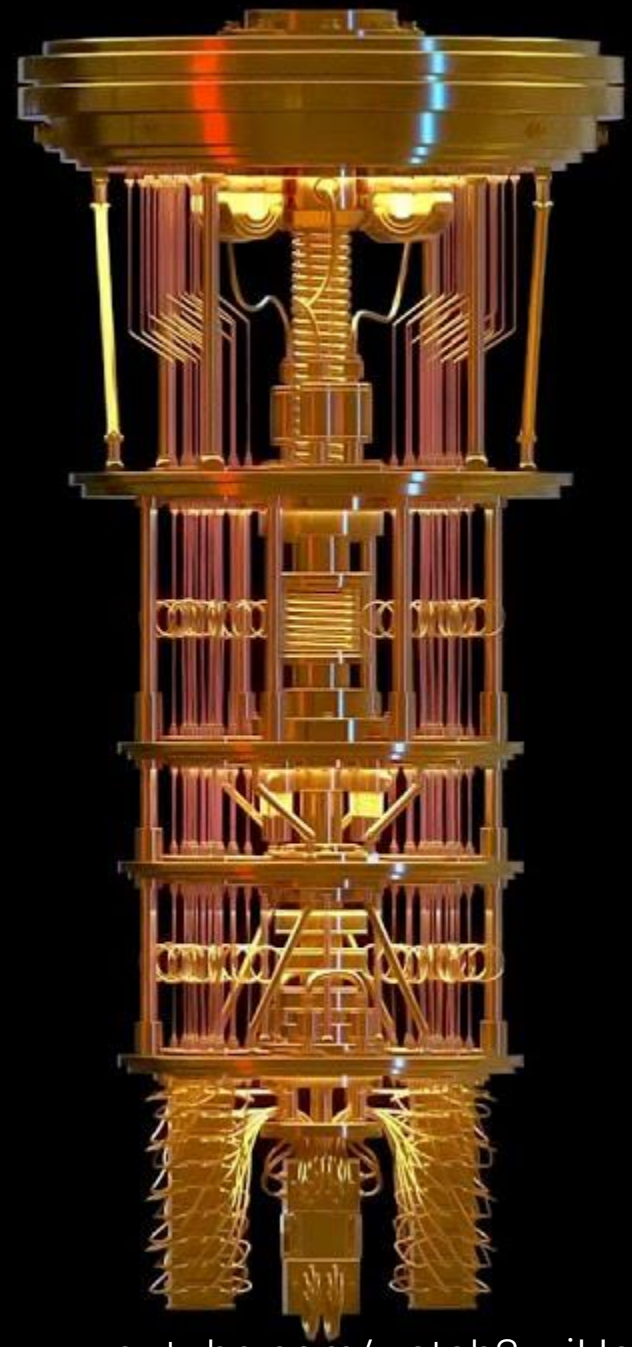


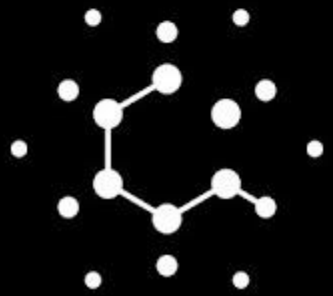
A solid-state background –digitalization and integration of computational food processing with food science and technology for industry x.0.


Cooling
Bakery
Fermentor 2

QUANTUM COMPUTING

Zetabyte -10^9 Terabyte





https://www.youtube.com/watch?v=jHoEjvuPoB8

Quantum Computers

Calculation time <4 min

The most powerful computer – 10,000 years

- Digital twin – Virtualization

(food process – manufacturing – controls for food safety!)