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INTERNATIONAL CONFERENCE ON SUSTAINABLE FOODS
Achieving the Sustainable Development Goals
July 24 25 2024

ArtiSaneFood – Innovative bio-interventions and risk modelling approaches for ensuring microbial safety and quality of Mediterranean artisanal fermented foods

ArtiSane Food

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PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

European Commission

CIMO Centro de Investigação de Montanha

ipb INSTITUTO POLITÉCNICO DE BRAGANÇA

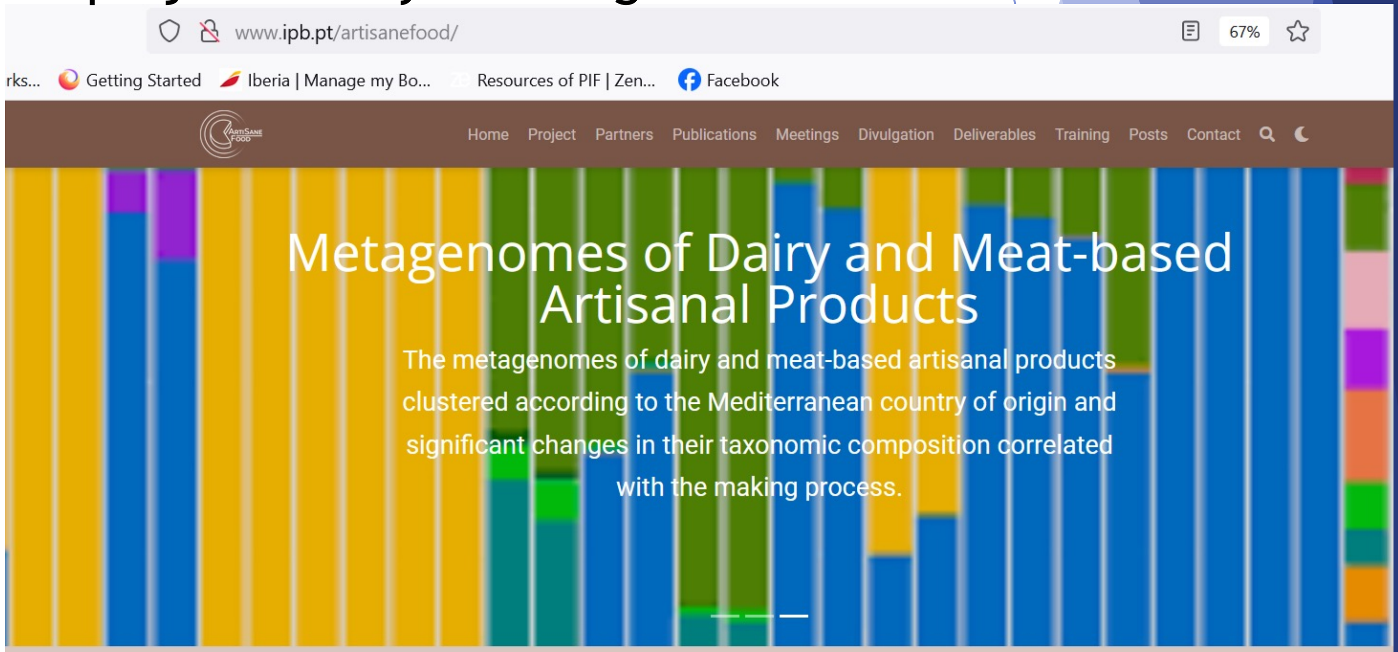
Content

- Background of the ArtiSaneFood project
  - Objectives, partners, food products
- Pillars: Biointerventions, fate studies, dynamic modelling, process control, process risk models
- The ArtiSaneFood free tool
  - Database
  - Process risk models

Background: The ArtiSaneFood project

- Duration: June 2019 – May 2023
- Objective: to develop efficient **bio-intervention strategies**, **enhanced process criteria**, and an **easy-to-use food safety decision support IT tool**, aiming to the reduction and control of food-borne pathogens in artisanal fermented foods of meat or dairy origin produced in the Mediterranean.

✓ First PRIMA project led by a Portuguese institution



- Website:
  http://www.ipb.pt/artisanefood/
- The decision-support tool
  https://arti-sane-food-frontend.vercel.app/
- Repository:
  https://zenodo.org/communities/artisanefood

Partners

- Portugal, Morocco, Tunisia, Spain, France, Italy, Greece

INSTITUTO POLITÉCNICO DE BRAGANÇA

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المدرسة العليا للتكنولوجيا -أكادير

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Sidi Thabet

سيدي ثابت

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anses agence nationale de sécurité sanitaire alimentation, environnement, travail

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ΓΕΩΠΟΝΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ AGRICULTURAL UNIVERSITY OF ATHENS

Artisanal foods

Alheira

Serrano

Manchego

Morcilla

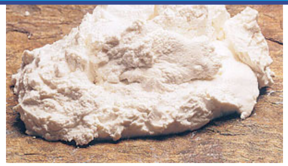
Squacquerone

Emilia-Romagna

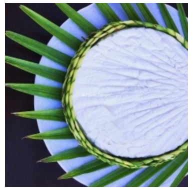
Camembert Normandy

Noumbulo

Katiki Domokou



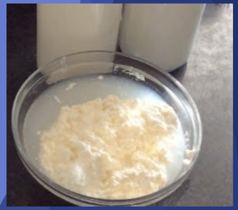
Jben



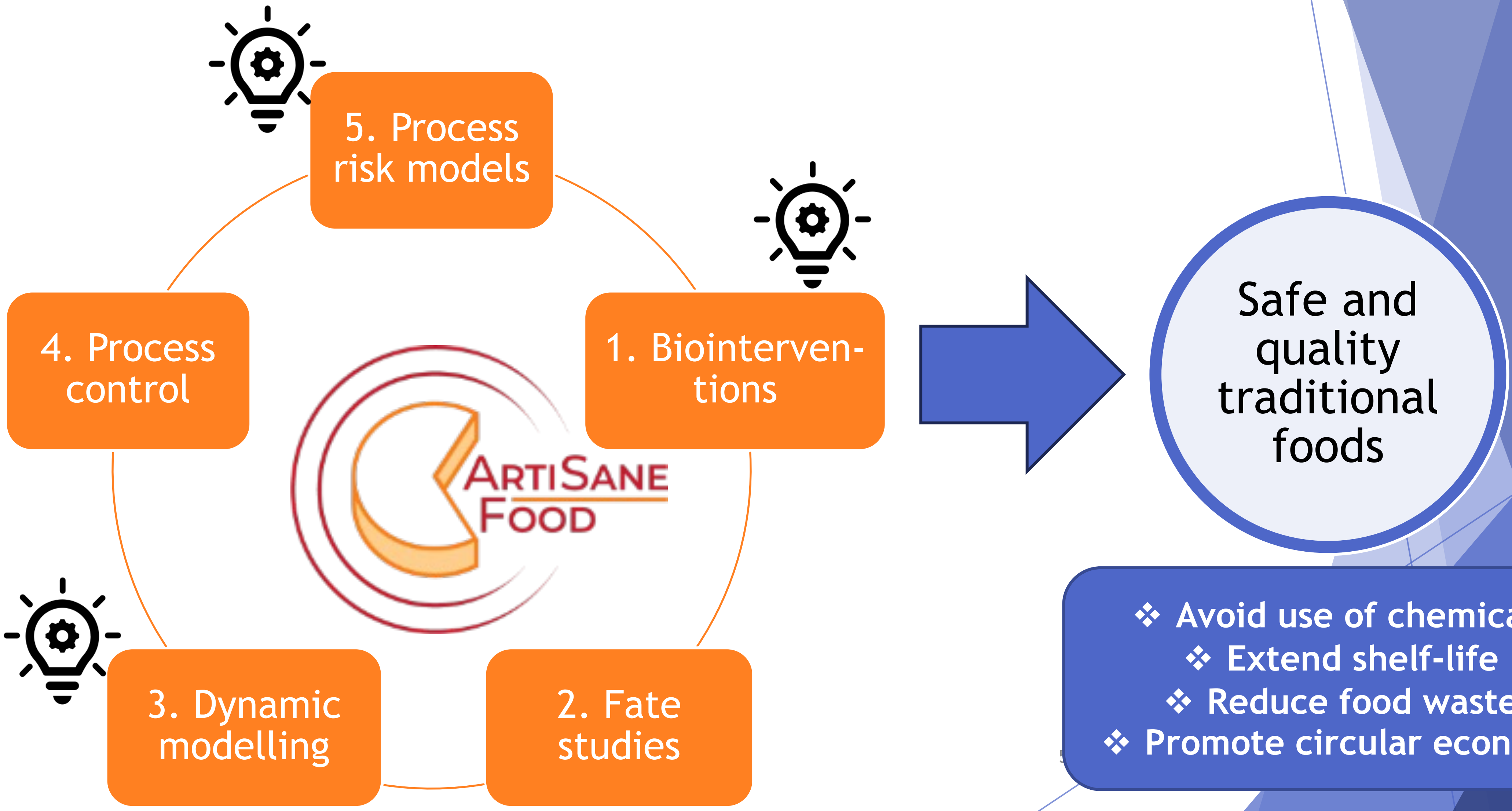
Merguez

Kaddid

Lben

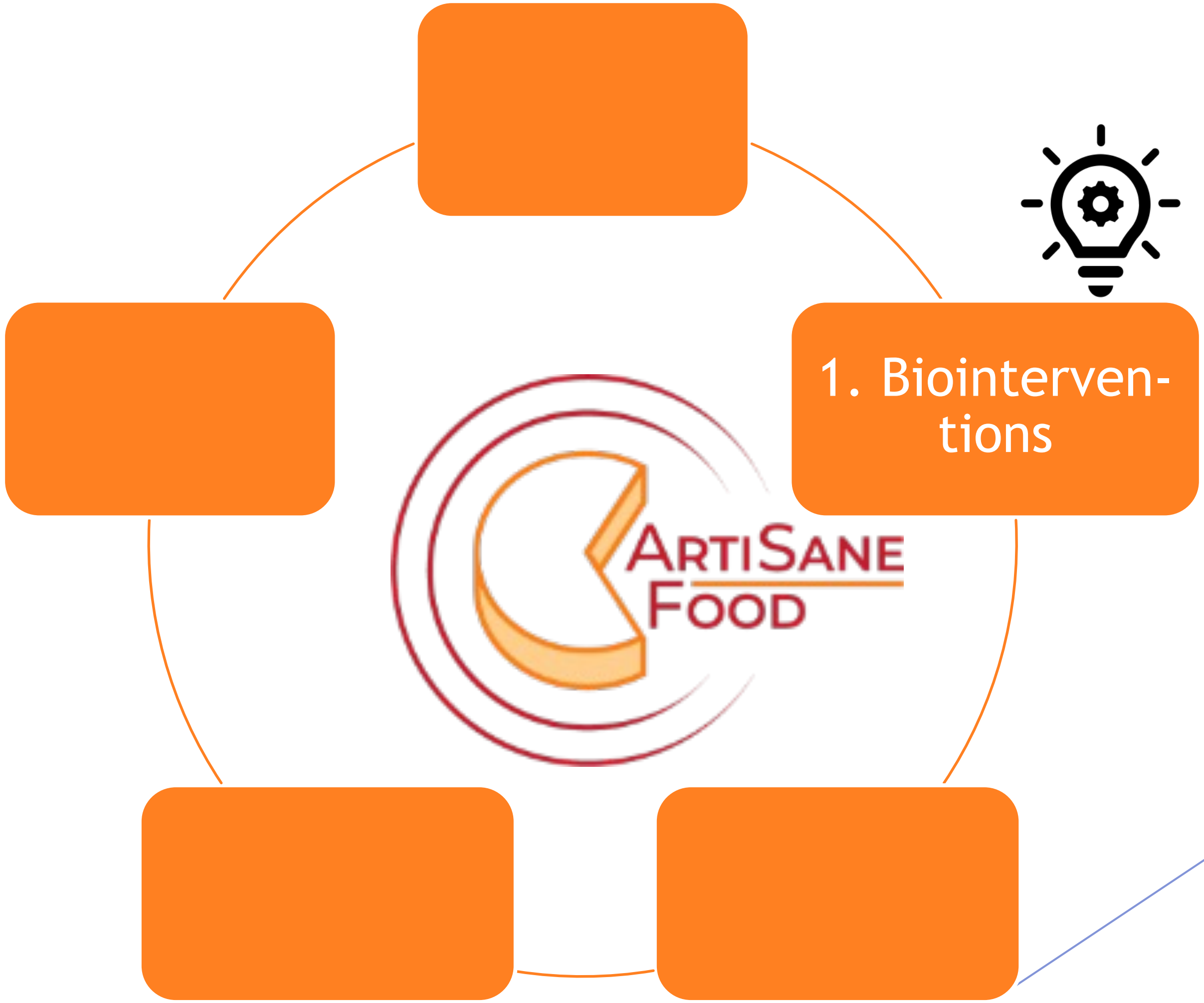


The Pillars of the project



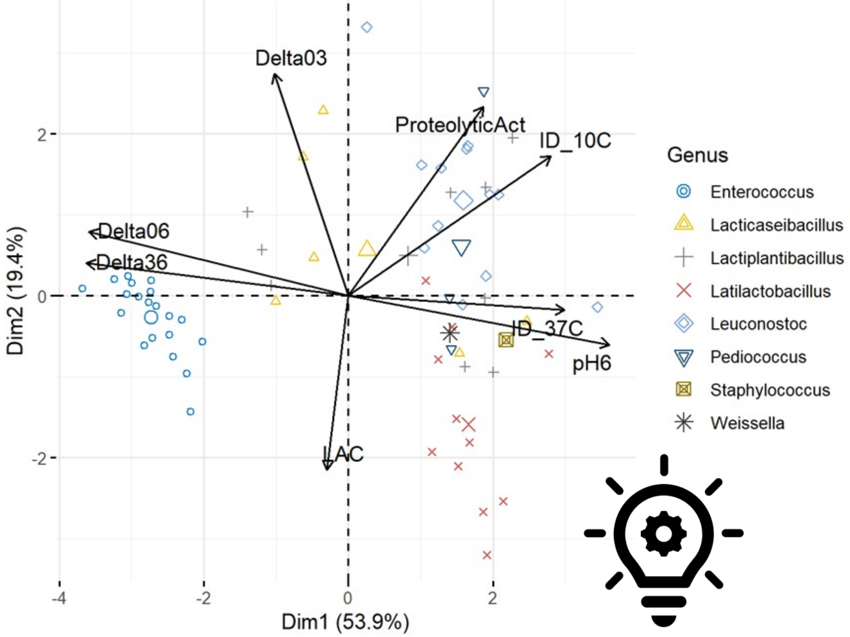
- ❖ Avoid use of chemicals
- ❖ Extend shelf-life
- ❖ Reduce food waste
- ❖ Promote circular economy

The Pillars of the project

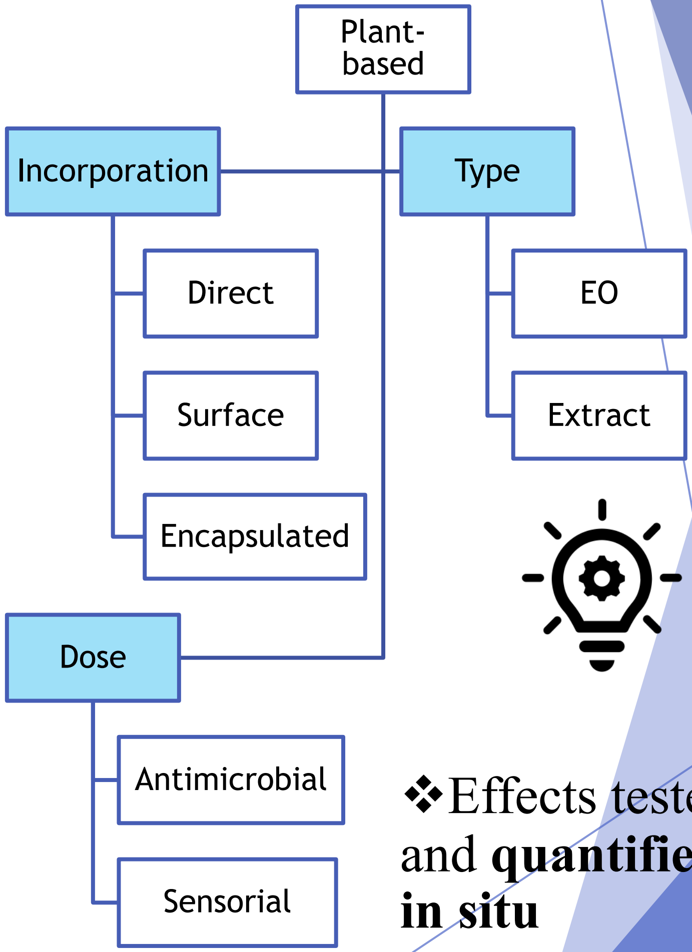


1. Biointerventions

- **Functional starter cultures**
  - Development of functional starters
    - ❖ Assessment and ID of potential LAB
    - ❖ Apart from technological properties, antimicrobial properties were **tested and quantified in situ**



- **Natural extracts** with antimicrobial properties



❖Effects tested and **quantified in situ**

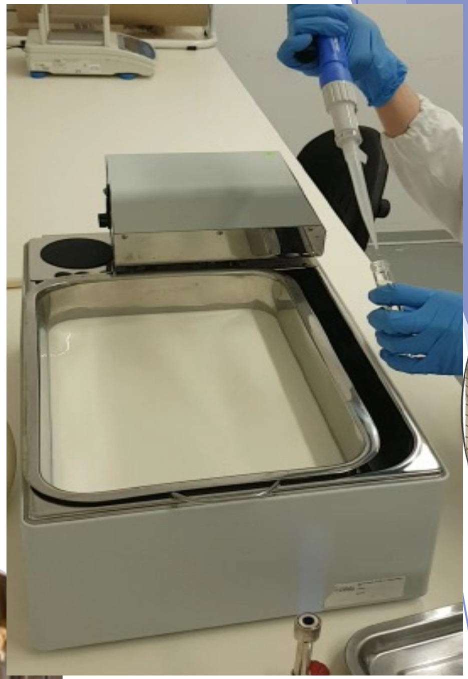
The Pillars of the project

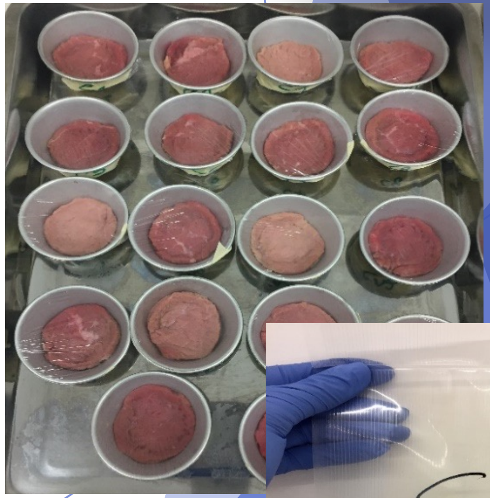
2. Fate studies

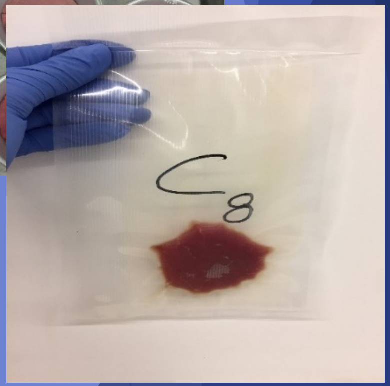
- In-situ evaluation of the growth or survival of selected foodborne pathogens (*Salmonella*, *L. mono*, *S. aureus*) **artificially inoculated** in the food to assess the effects of (bio-)interventions

- Treatments
  - Control
  - Improved process criteria
  - Added lactic acid bacterium/cultures
  - Added extracts or EOs

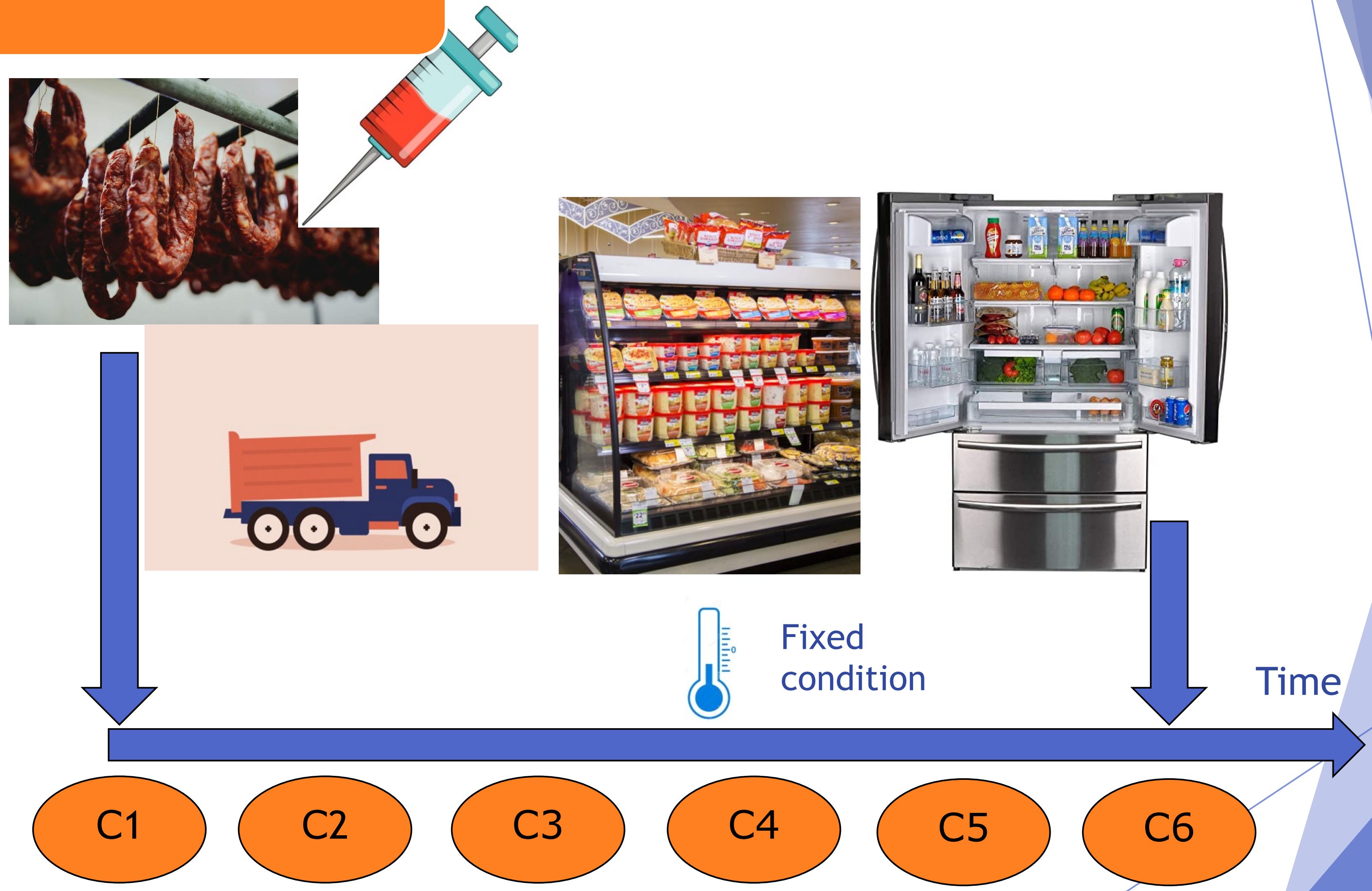
- Stage of monitoring (CCP?)
  - Fermentation
  - Maturation or curing
  - Storage (shelf life)



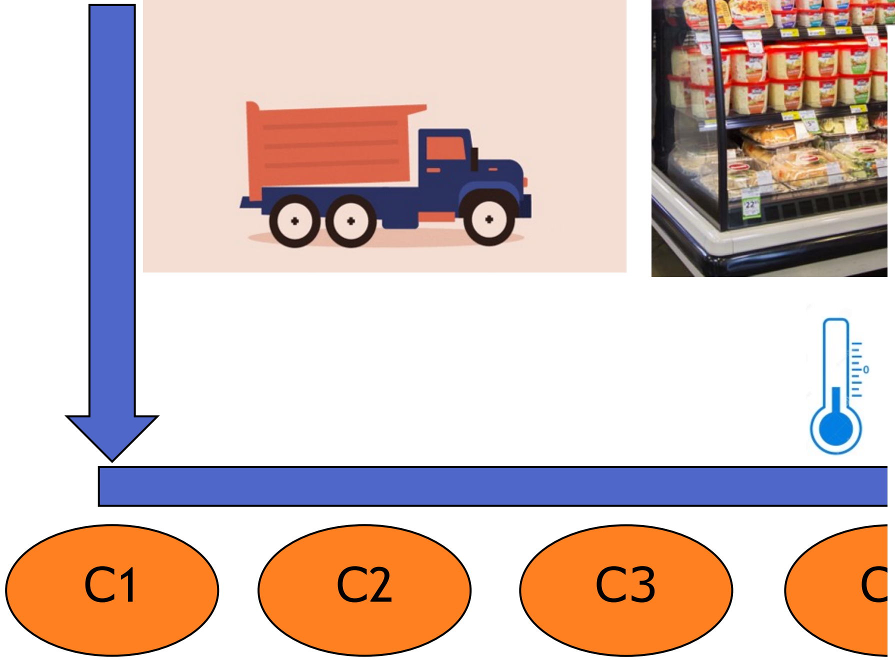


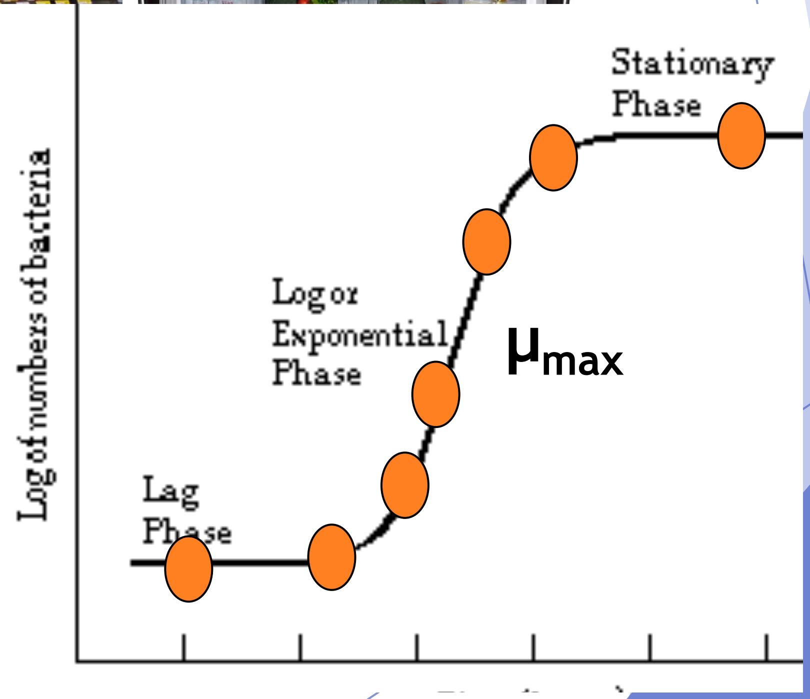


2. Fate studies



2. Fate studies



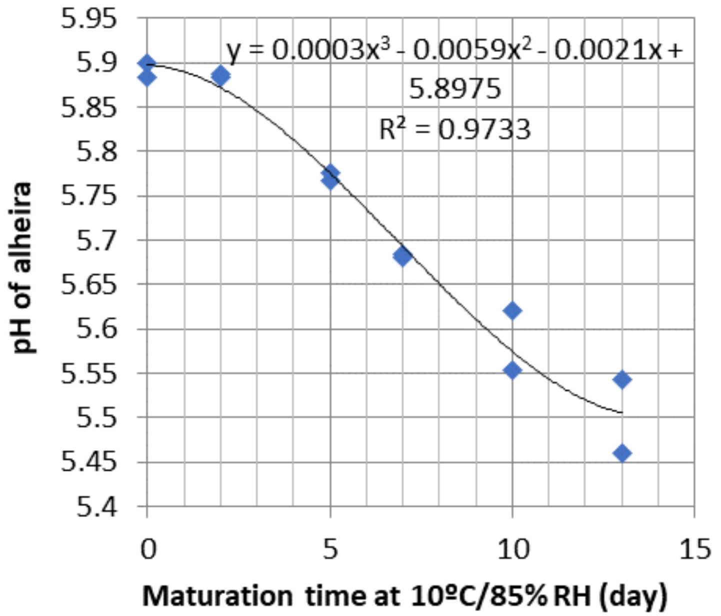


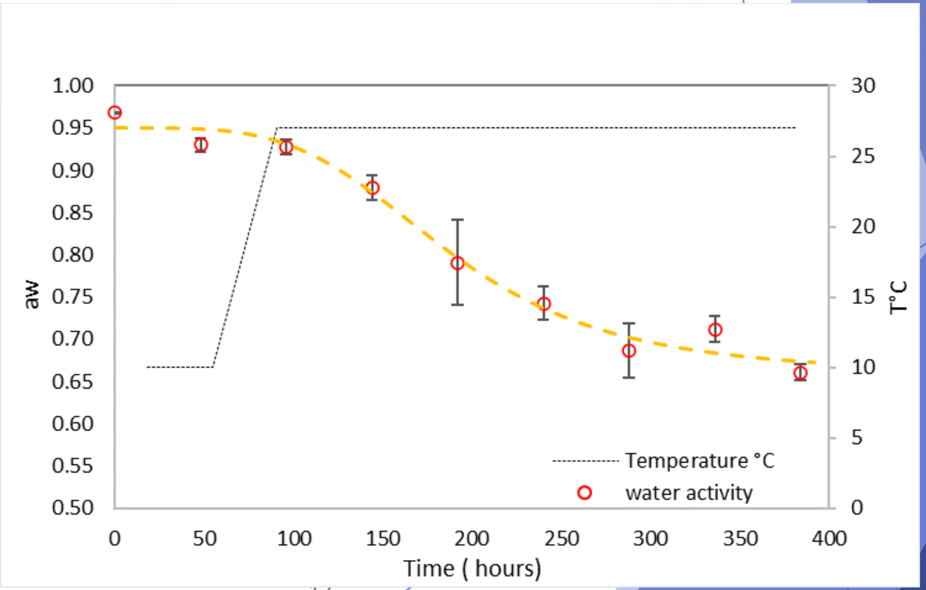
2. Fate studies

- Nonetheless our fate studies are characterised for having no fixed conditions

❖Product: Alheira
❖Stage: Maturation
❖Changing property: pH
❖Treatment: Control

❖Product: Merguez
❖Stage: Fermentation and drying
❖Changing properties: aw and temperature
❖Treatment: Control



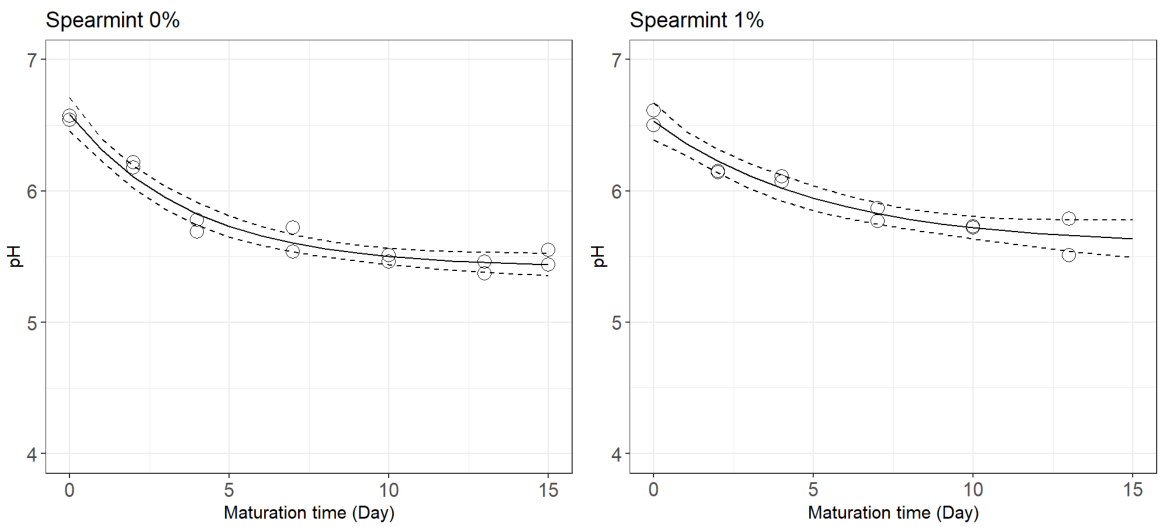


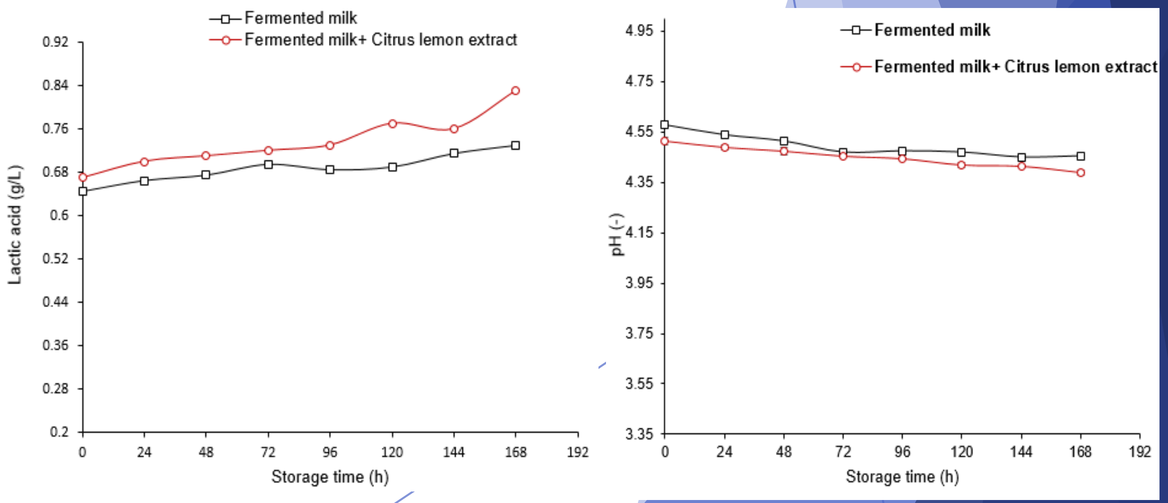
2. Fate studies

- Consider that some bio-interventions further affect the evolution of the changing properties (!)

❖Product: Raw milk cheese
❖Stage: Maturation
❖Changing property: pH
❖Treatment: Addition of 1% spearmint extract

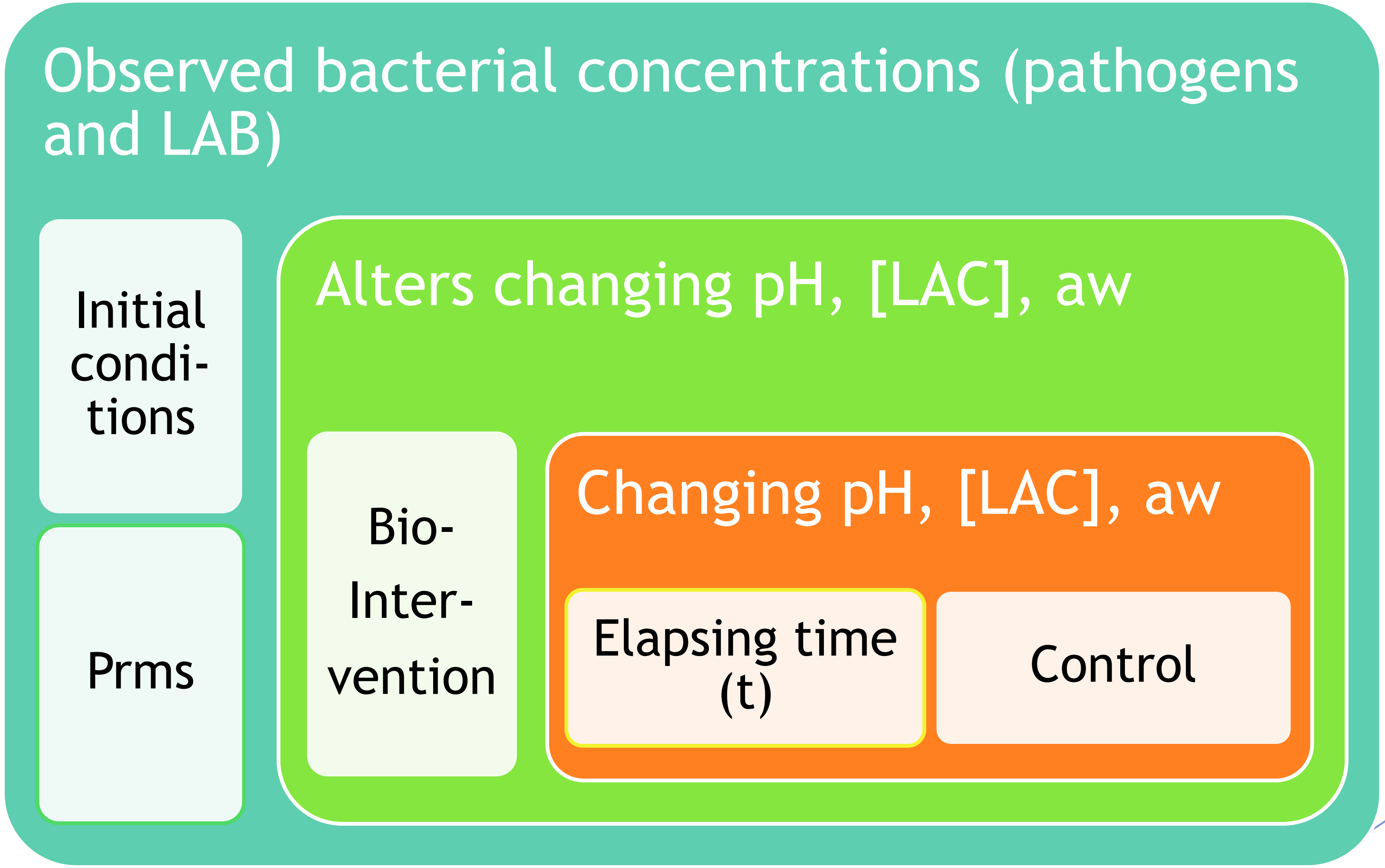
❖Product: Fermented milk
❖Stage: Cold storage
❖Changing properties: pH and acidity
❖Treatment: Addition of lemon extract





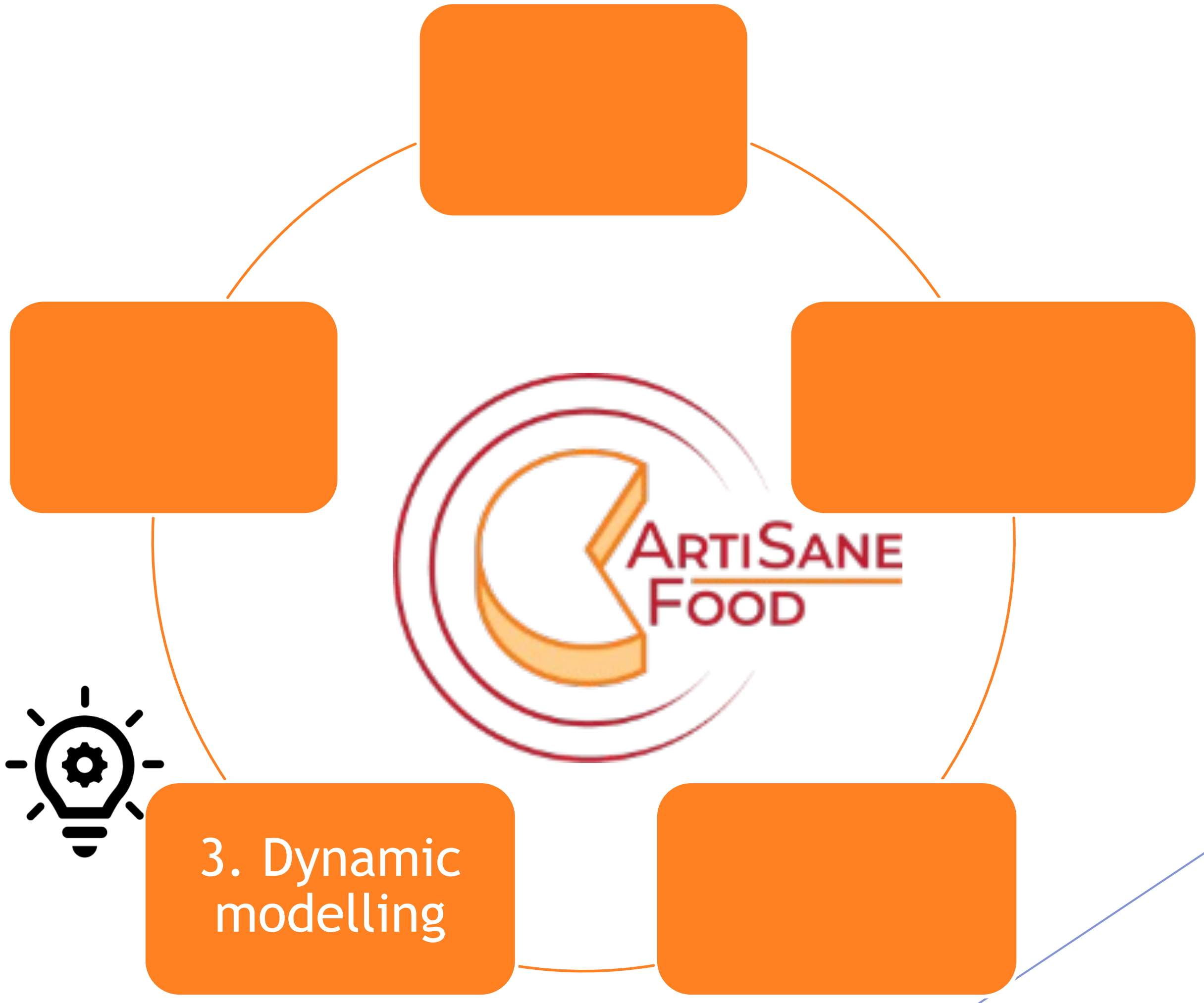
2. Fate studies

- Modelling is challenging, because of dynamic data and interactions:



- Dynamic data:
  - Fermented food products
- Interactions:
  - Kinetic parameters <-> Bio-interventions

The Pillars of the project



3. Dynamic modelling

- Predictive microbiology: controlling factors in foods and responses of pathogenic and spoilage microorganisms are quantified and modelled by mathematical equations

- The main problems are:
  - The kinetic parameters that depend on environmental parameters cannot be treated as constant, then resort to derivatives

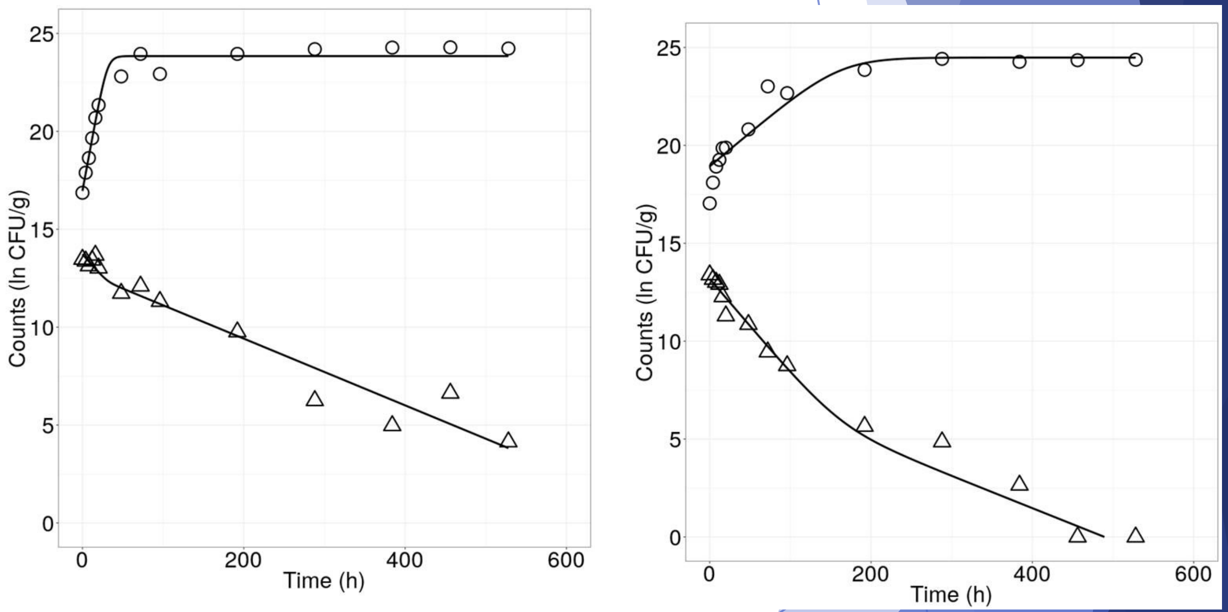
$$\int_{N_0}^{N_t} \frac{dN}{N} = \int_0^t \mu dt$$

  - Lactic acid bacteria may (or not) retard the development of foodborne pathogens

Dynamic microbial competition	Dynamic effect of environment
↓	↓
Inactivation	Inactivation
↓	↓
Growth	Growth

3. Dynamic modelling

L. monocytogenes was inactivated by added LAB culture in fermented sausage at two different storage temperatures



Dynamic microbial competition

Inactivation

3. Dynamic modelling

Jameson-effect competition model with gamma interaction parameter

$$\frac{1}{N_{LM}}\frac{dN_{LM}}{dt} = \mu_{LM}\left(1 - \frac{N_{LM} + \gamma N_{LAB}}{N_{\max tot}}\right)$$

$$\frac{1}{N_{LAB}}\frac{dN_{LAB}}{dt} = \mu_{LAB}\left(1 - \frac{N_{LAB}}{N_{\max tot}}\right)$$

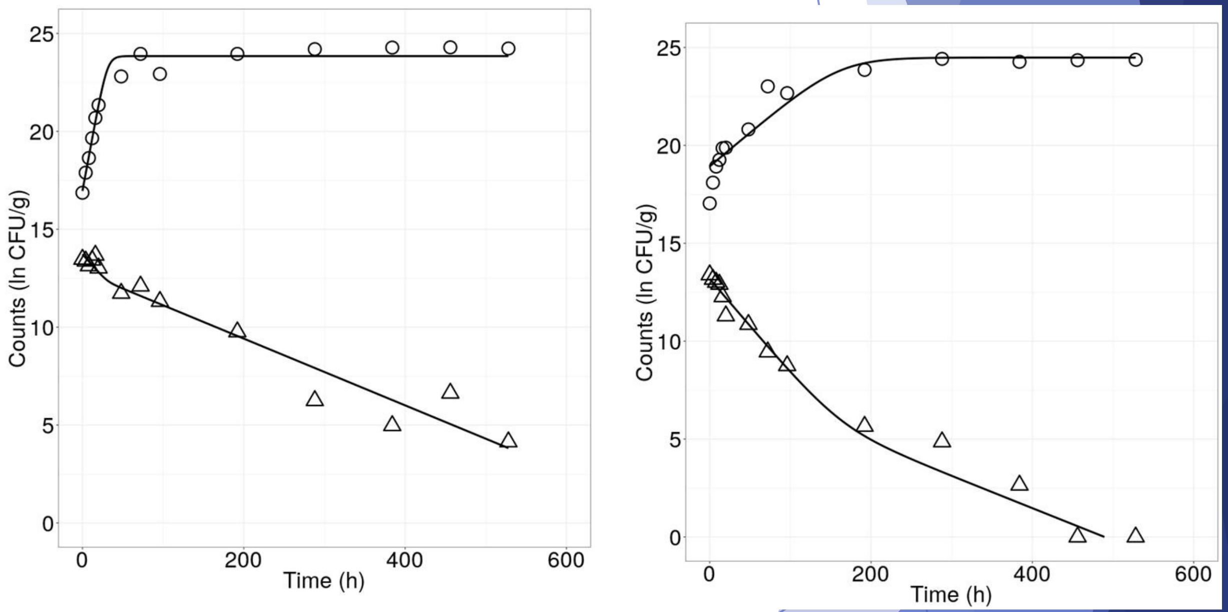
If $\mu_{LM} > 0$:

- $\gamma < 1$: LM still grows after LAB reaches a maximum
- $\gamma > 1$: LM stops growing after LAB reaches a maximum

If $\mu_{LM} < 0$:

- $\gamma > 1$: when LAB reaches maximum growth, LM population can become less sensitive to the inhibitory effect of LAB

L. monocytogenes was inactivated by added LAB culture in fermented sausage at two different storage temperatures



ln(γ)	0.632 (SE=0.188) γ=1.88 at 10 ºC	0.661 (SE=0.077) γ=1.94 at 5 ºC

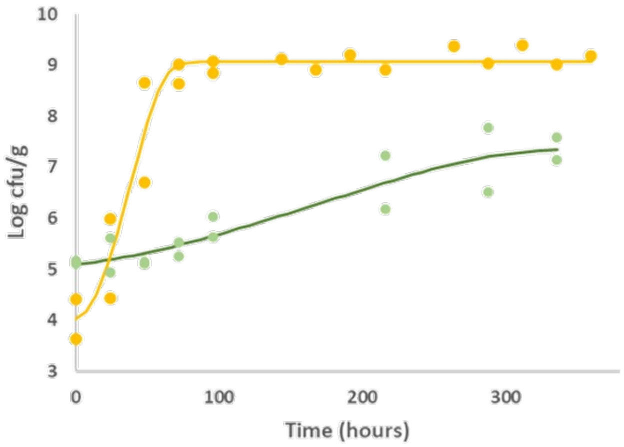
3. Dynamic modelling

- *L. monocytogenes* grows in *salchichón* sausage during storage, but its growth is delayed by added LAB culture

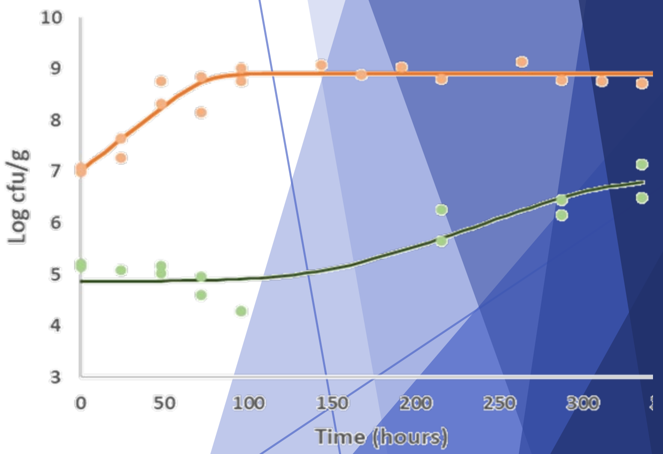
Dynamic microbial competition

Growth

(A) Autochthonous LAB



(B) +Starter culture



3. Dynamic modelling

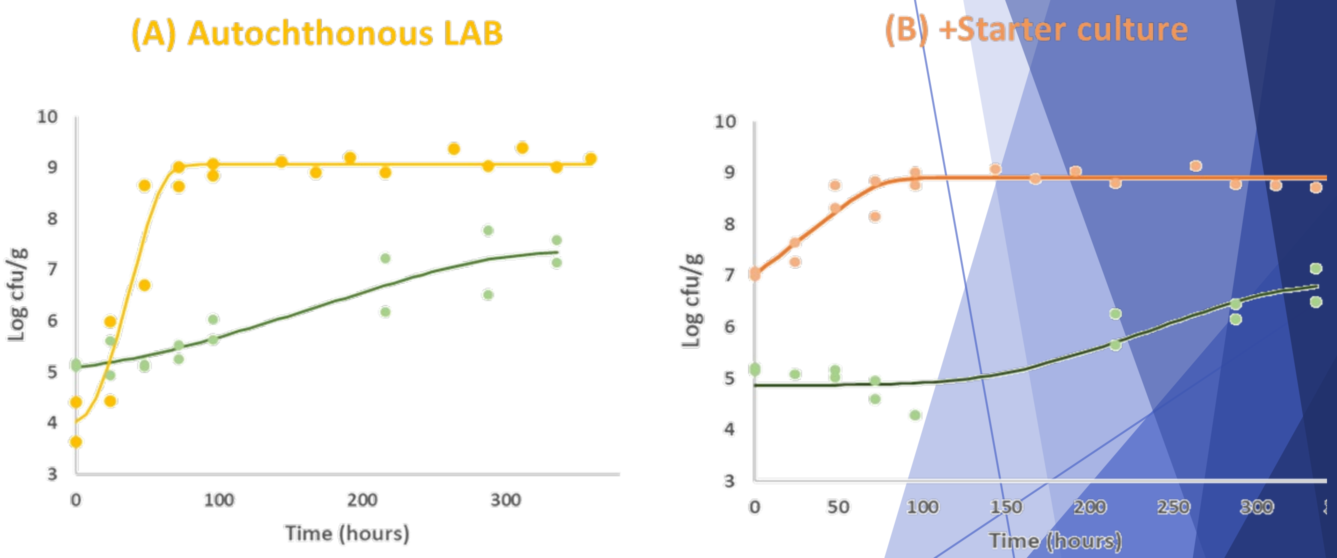
- Lotka-Volterra competition model with alpha interaction parameter

$$\frac{1}{LM}\frac{dLM}{dt} = \mu_{LM}\left(1 - \frac{LM + \alpha_{\mathrm{LM}-LAB} \times LAB}{LM_{max}}\right)$$

$$\frac{1}{LAB}\frac{dLAB}{dt} = \mu_{LAB}\left(1 - \frac{LAB}{LAB_{max}}\right)$$

- **If $\alpha_{\mathrm{LM}-LAB} = 0$:**
- No effect of LAB, each bacterial group grows independently
- A good way to test if there is really inhibition effect

- *L. monocytogenes* grows in *salchichón* sausage during storage, but its growth is delayed by added LAB culture

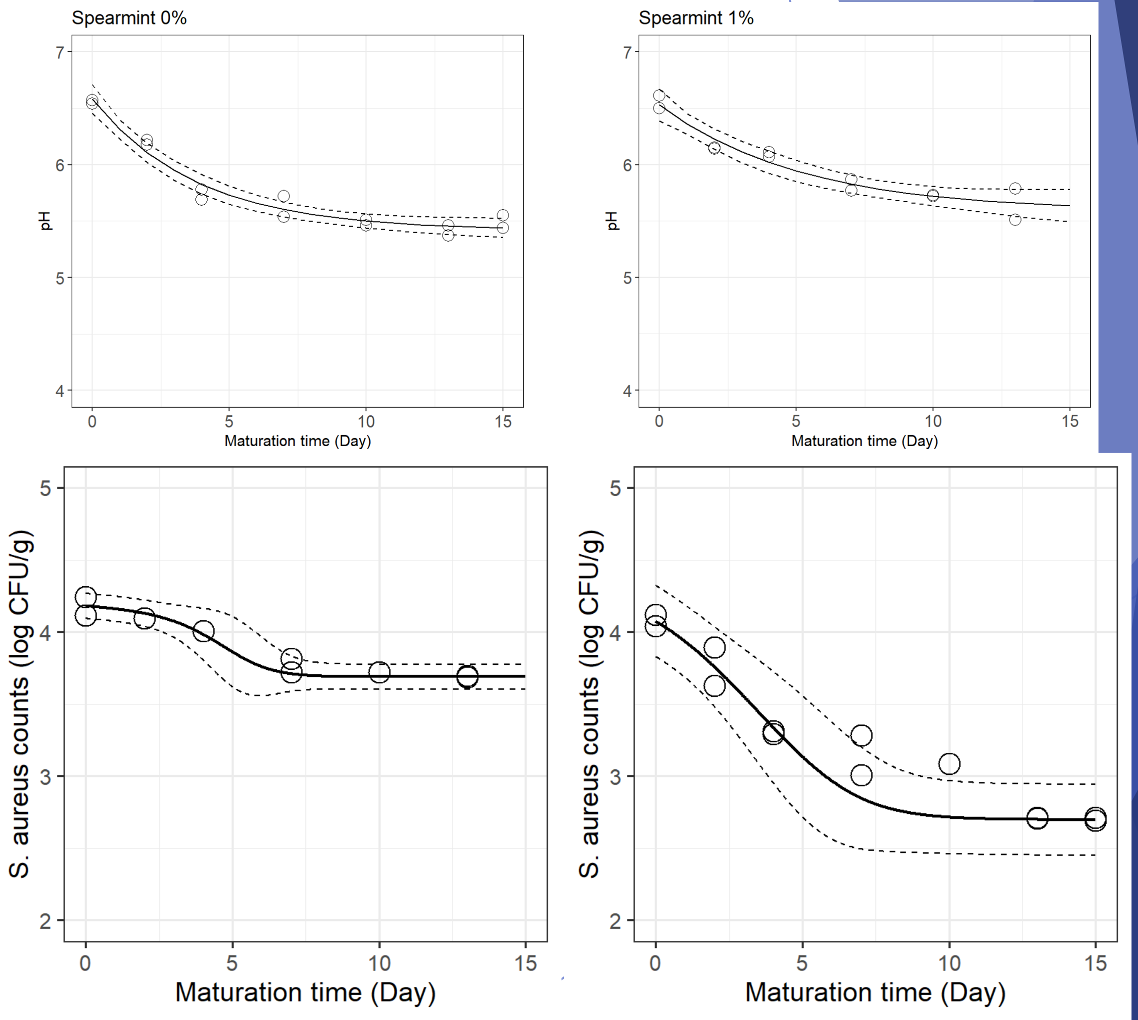


3. Dynamic modelling

Dynamic effect of environment

Inactivation

- *S. aureus* in raw milk cheese is inactivated during maturation, and it is further inactivated by adding spearmint extract in goat's milk cheese,
- pH changes during maturation



3. Dynamic modelling

- Geeraerd inactivation model coupled with Bigelow model for pH

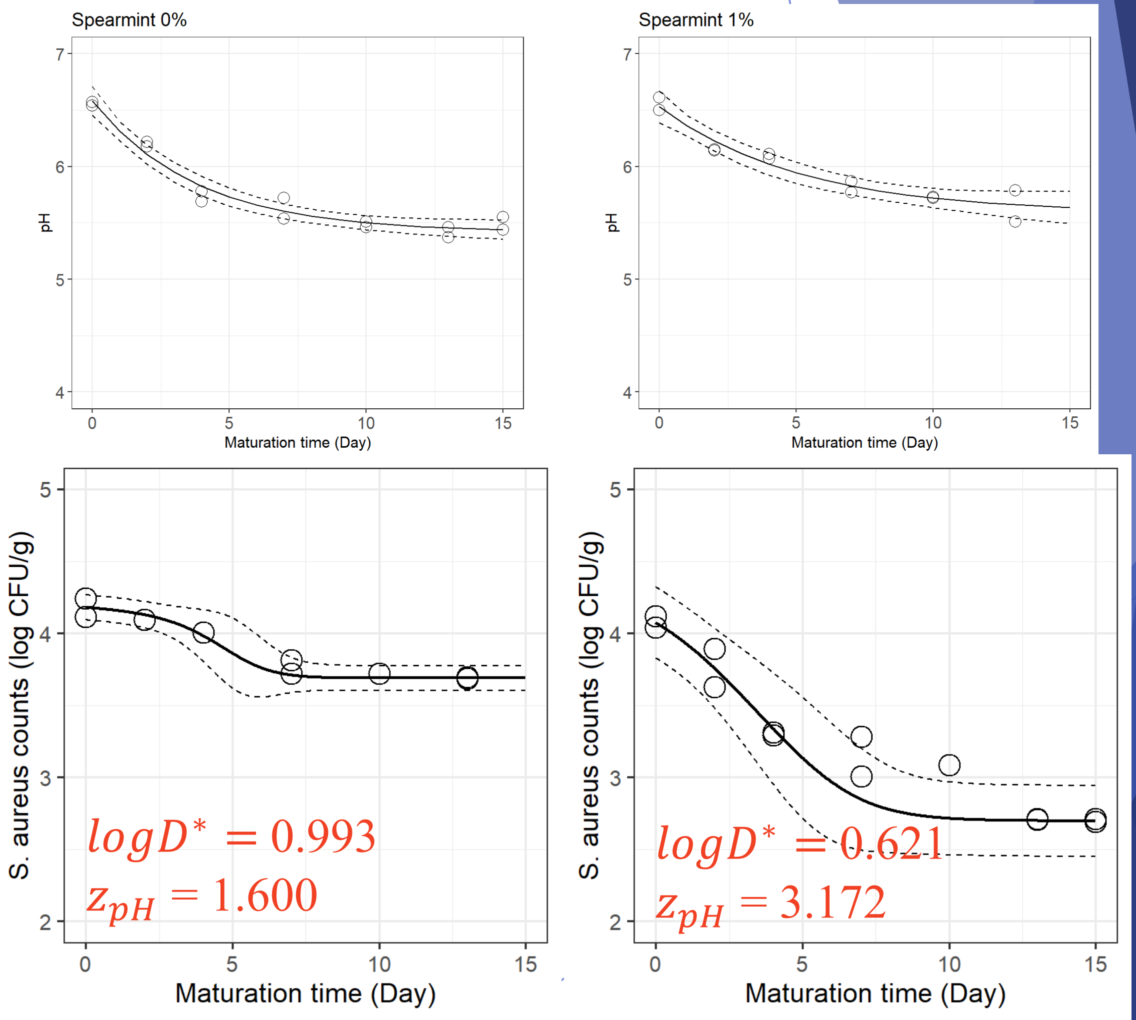
$$\frac{dN}{dt} = -kN\left(\frac{1}{1+C_c}\right)\left(1-\frac{N_{res}}{N}\right)$$

$$\frac{dC_c}{dt} = -kC_c$$

$$D = \frac{\log(10)}{k}$$

$$\log D = logD^* - \left(\frac{pH - pH^*}{z_{pH}}\right)^2$$

- *S. aureus* in goat's milk cheese is inactivated during maturation, and it is further inactivated by adding spearmint extract in goat's milk cheese,
- pH changes during maturation



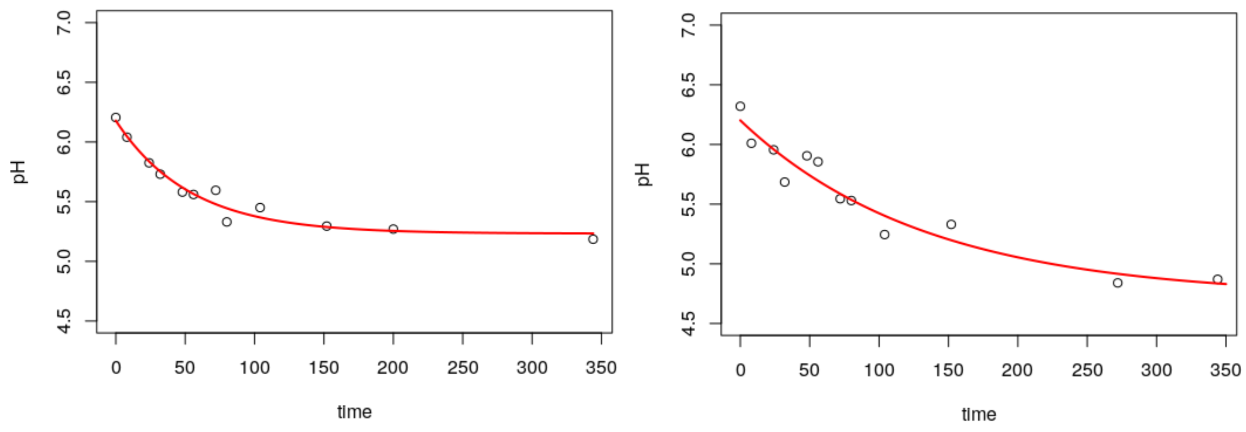
3. Dynamic modelling

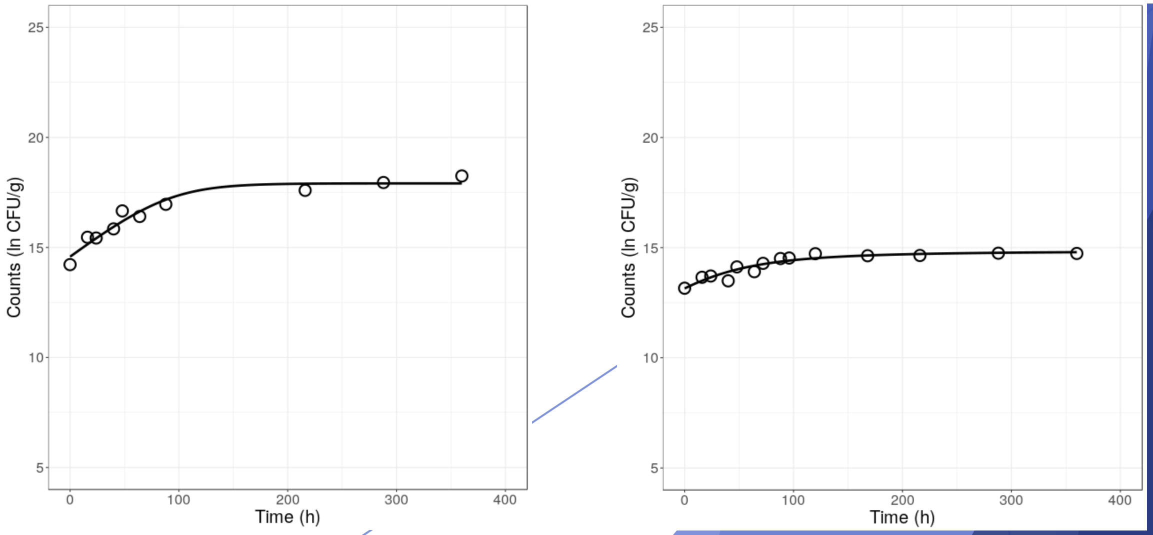
- *L. monocytogenes* in soft cheese grows during curing in both, without added starter culture and with added starter culture
- pH profiles are different

Dynamic effect of environment

Growth

No added culture | Added culture





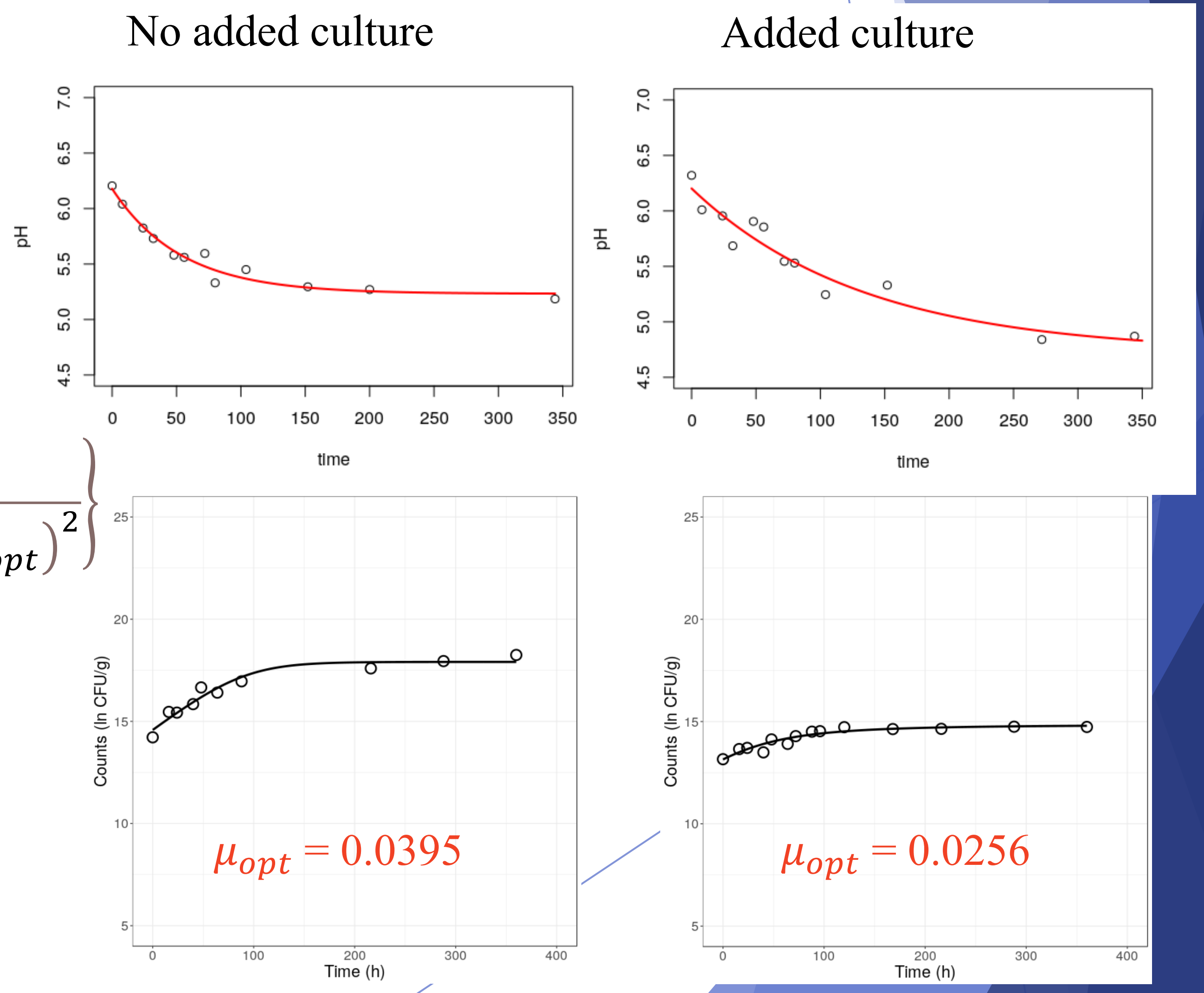
3. Dynamic modelling

- Huang growth model coupled with cardinal parameter model for pH and aw

$$\frac{dY}{dt} = \frac{\mu_{max}}{1 + e^{-4(t-\lambda)}}\left(1 - e^{Y - Y_{max}}\right)$$

$$\mu_{max} = \mu_{opt}\left\{\frac{(pH - pH_{min})(pH - pH_{max})}{(pH - pH_{min})(pH - pH_{max}) - (pH - pH_{opt})^2}\right\} \times \left\{\frac{a_w - a_{w\,min}}{1 - a_{w\,min}}\right\}$$

- *L. monocytogenes* in soft cheese grows during curing in both, without added starter culture and with added starter culture
- pH profiles are different



The Pillars of the project

4. Process control

Food safety control system

1. Knowledge of factors necessary for control
2. Knowledge of extent of variability and factors that influence variability
3. Establishing criteria for the factors that must be controlled
4. Establishing monitoring procedures
5. Organising and interpreting data
6. Using the data to improve control and measure change
7. Investigating and learning from unforeseen events

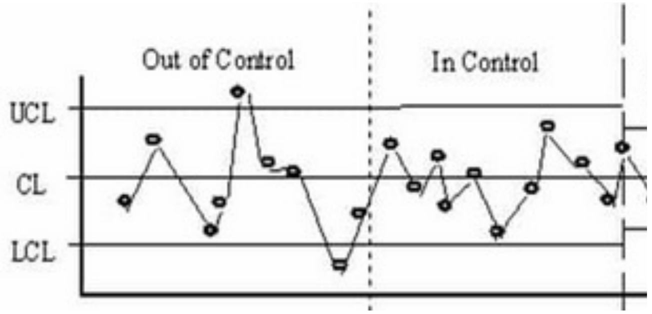
Variability between lots assessed, since it must be small in comparison to variability within a lot

Detect process deviations (when it has gone out-of-control)

4. Process control

Verification testing

Can rely on **statistical process control** to make informed decisions about the capability of a process to produce safe food



- ✓ Standards
- ✓ Quality monitoring tools

Process control verification can be applied at any point in the food chain

Regulatory verification: use of a **microbiological criterion** to demonstrate that the upstream process is under control

Processing of fermented sausages

Reception of raw materials
Mixing
Stuffing
Fermentation
Smoking
Maturation
End product

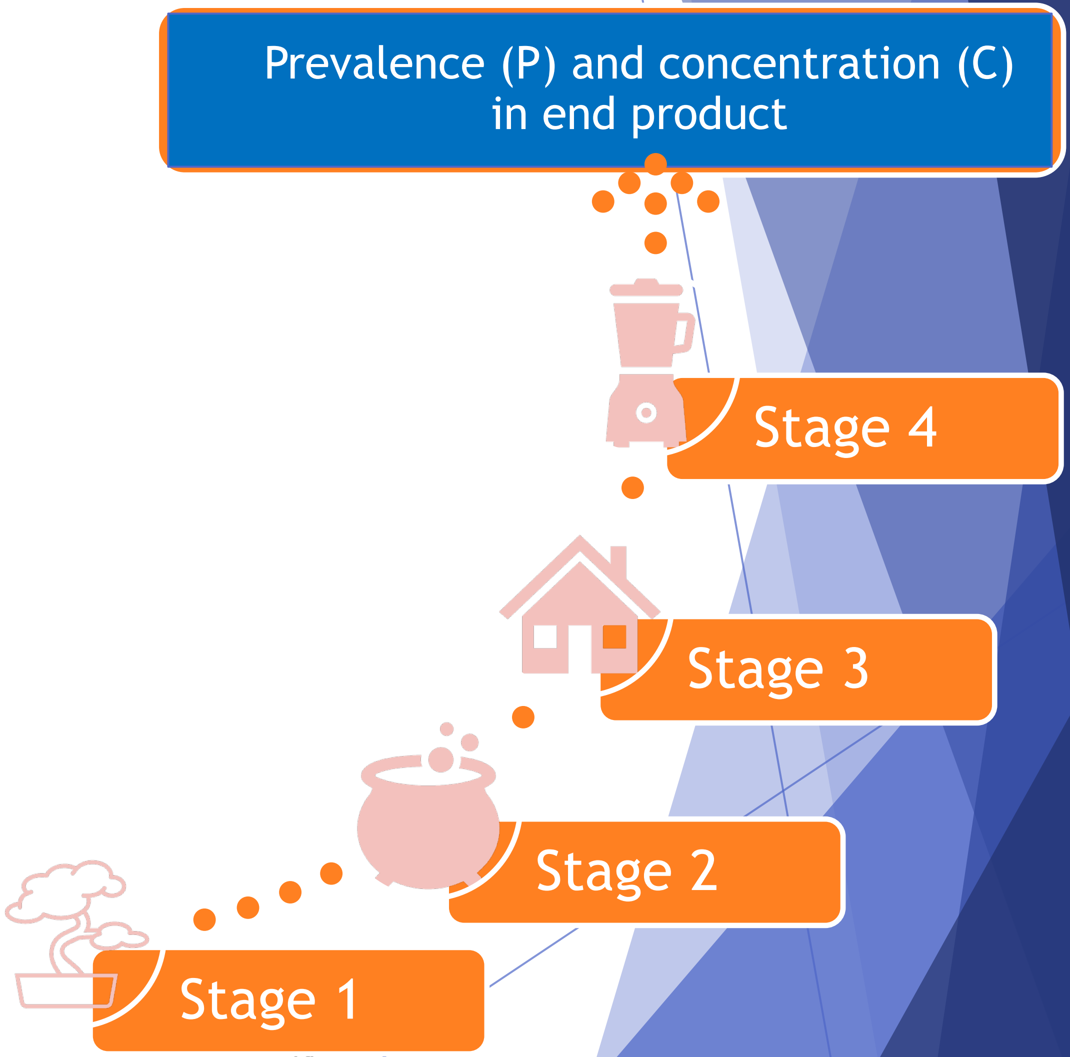
The Pillars of the project

5. Process risk models

- A process risk model is an exposure assessment model that describes the pathways of a foodborne pathogen along processing

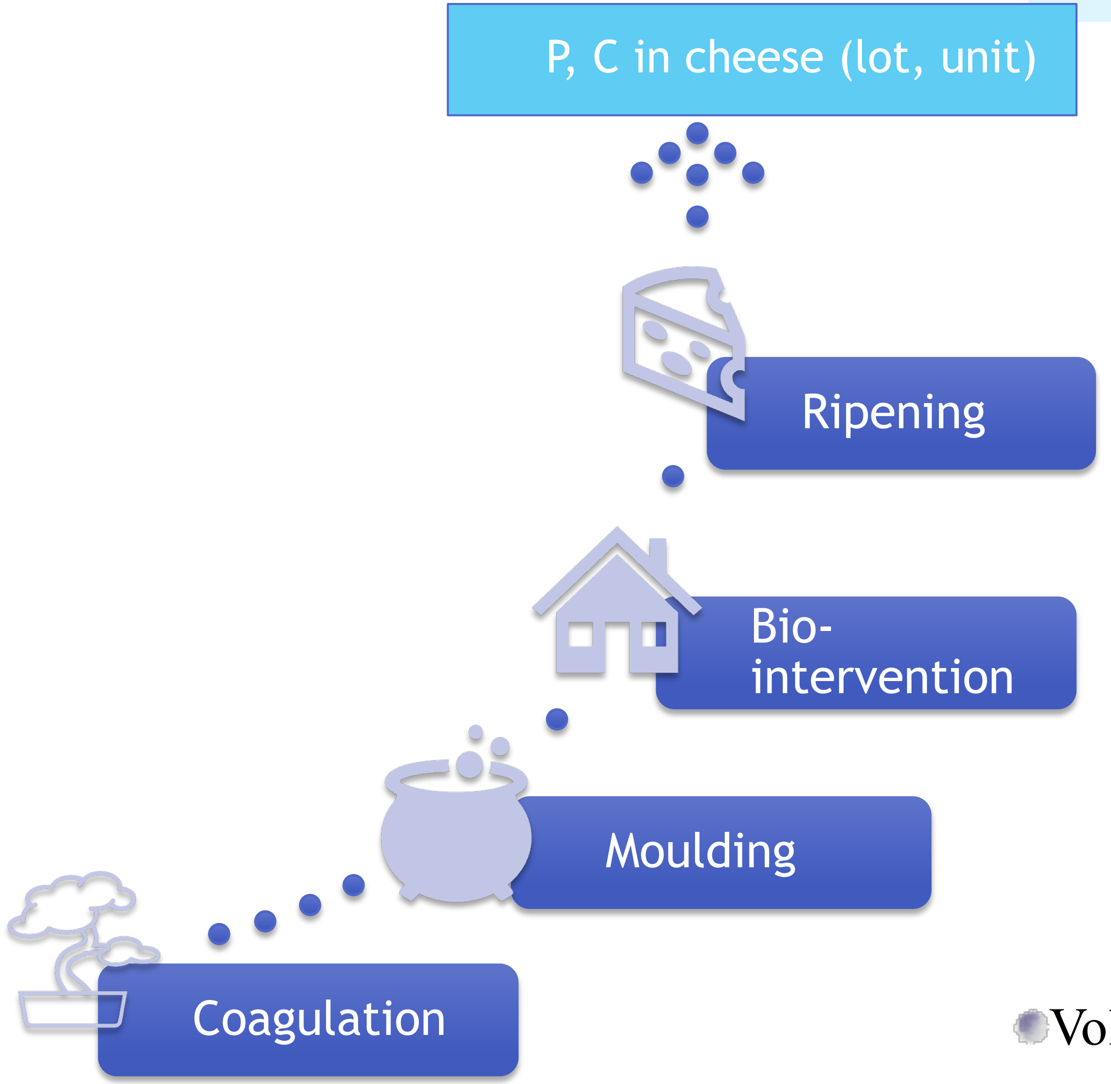
Process risk model

Initial P and C	Process variables	Microbial kinetics
✓ **Surveys in factories**	✓ **Standards** ✓ **Bio-interventions**	✓ **Dynamic models** ✓ **Effect of bio-interventions**



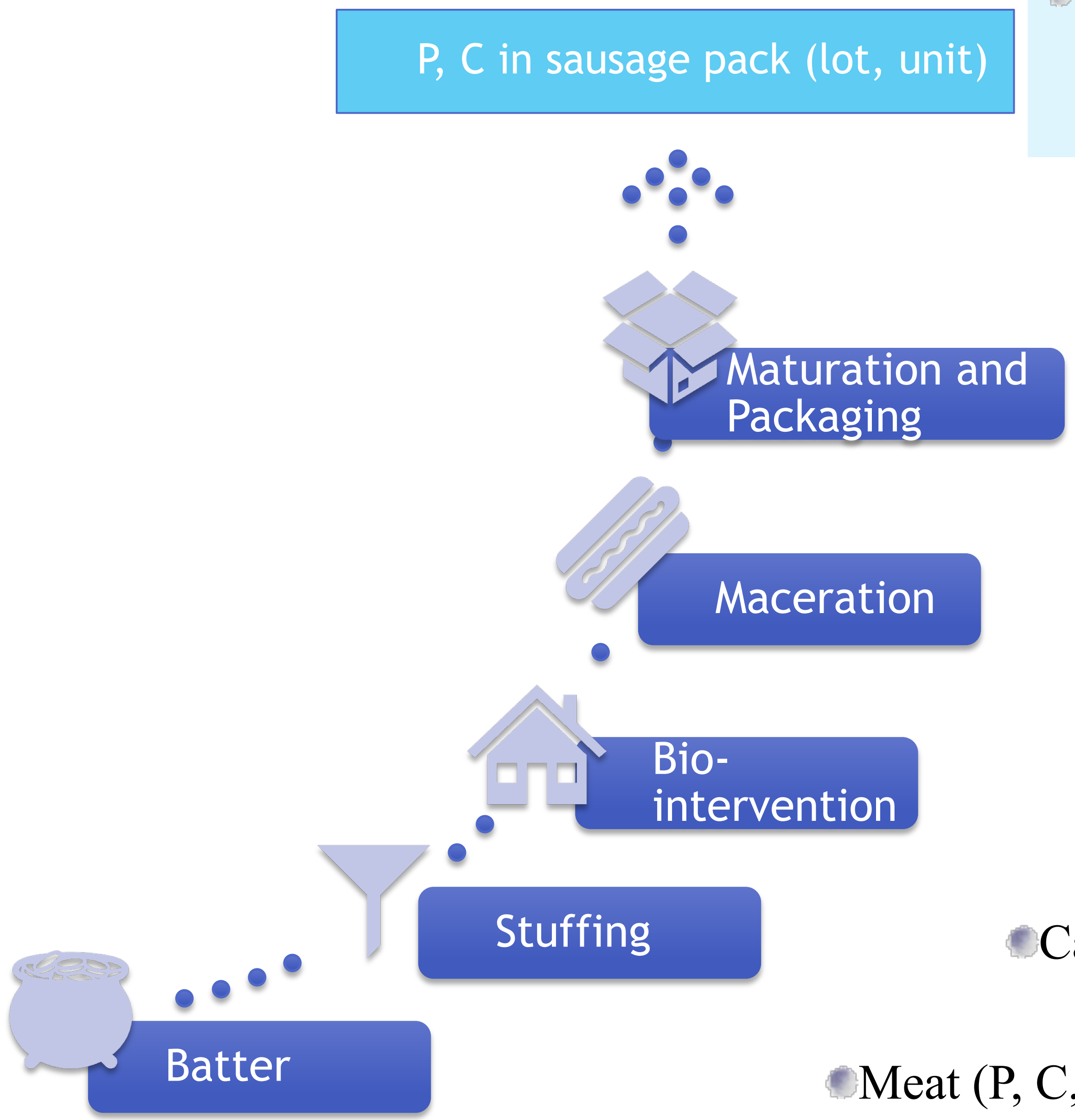
5. Process risk models

- Generic model for cheesemaking
  - Customisable for any cheese and fermented milk
  - *L. monocytogenes* only



- Time (min, mode, max), Temp (min, mode, max), N_{LAB} (min, mode, max), a_w (min, mode, max), pH (min, mode, max), [LAC] (min, mode, max), $\mu_{maxref\ Path}$ (mean, sd), $\mu_{maxref\ LAB}$ (mean, sd), MPD_{Path}, MPD_{LAB}
- Reduction (min, mode, max) if extracts added
- W_{cheese}, $rho_{Pressed}$, Yield, Dispersion
- Vol_{milk}, C(mean, sd), P_{lot}, $f_{entrapped}$

- Generic model for sausage
  - Customisable for any fermented sausage
  - *L. monocytogenes, Salmonella* or *S. aureus*



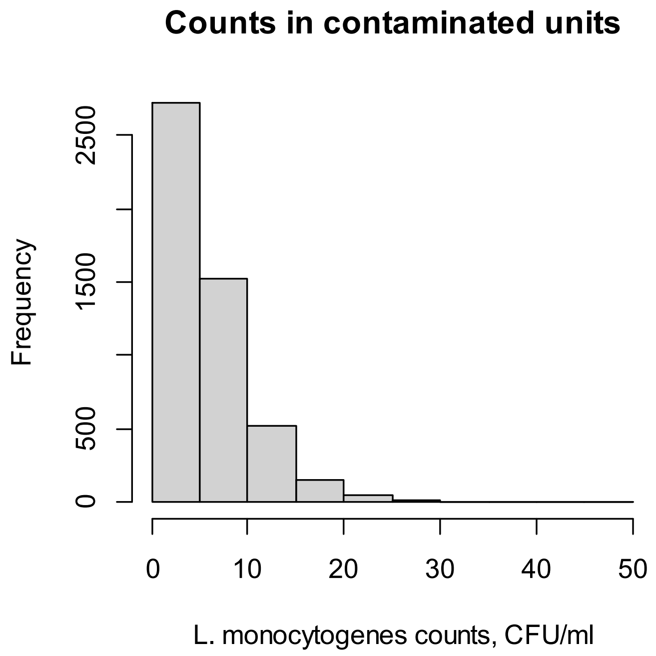
- pH_0, Time, $D_{ref(pH=7.0)}$ (mean, sd), z_{pH}, [LAC] (min, mode, max), $\mu_{maxref\ Path}$ (mean, sd), Lag decay, $Sausages_{Pack}$
- Time (min, mode, max), Temp (min, mode, max), $EGR_{5^{o}C}$ (mean, sd), MPD_{Path}, T_{min}, Lnq0 (mean, sd)
- Reduction (min, mode, max) if extracts added
- Casings (P_{lot}, N), Dispersion
- Meat (P, C, prop), Fat (P, C, prop), Spices (P, C, prop)

5. Process risk models

- The PRM enabled the assessment of the safety of the actual manufacturing processes, and those with potential interventions.

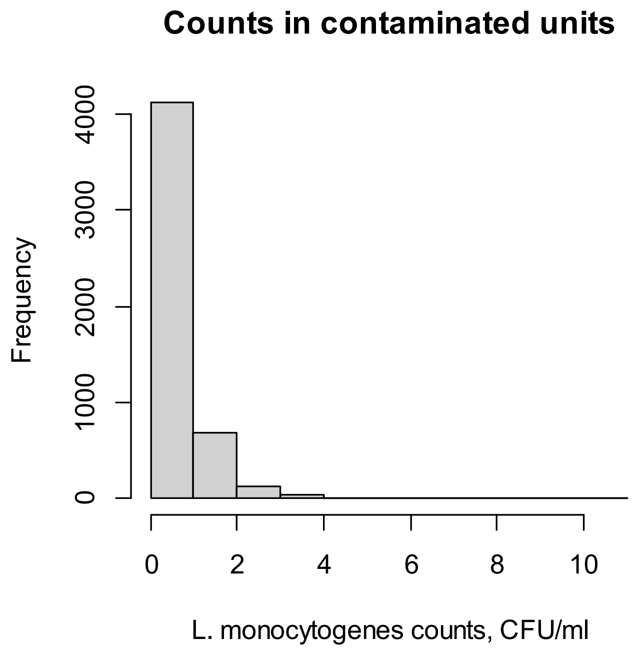
Lben fermented milk

- Baseline (Prev=0.05)



Lben fermented milk

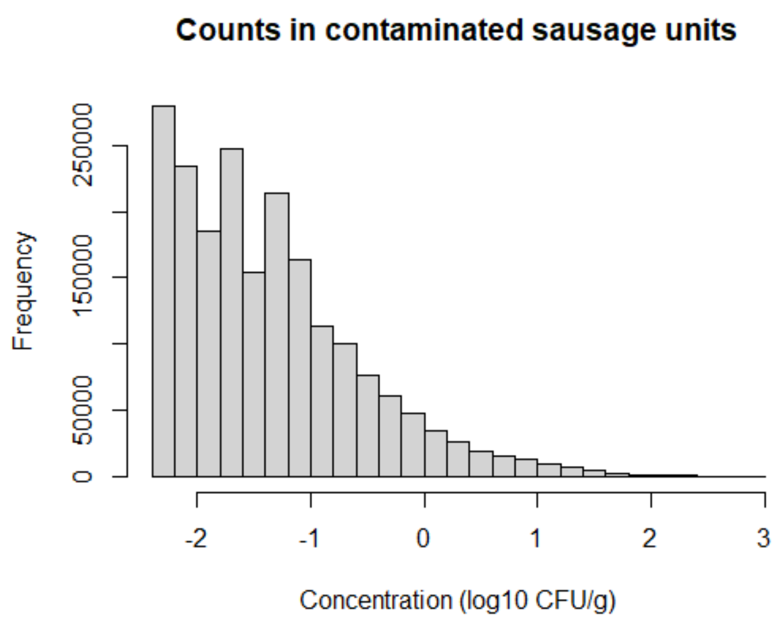
- Added with citrus peel extract (Prev=0.05)



5. Process risk models

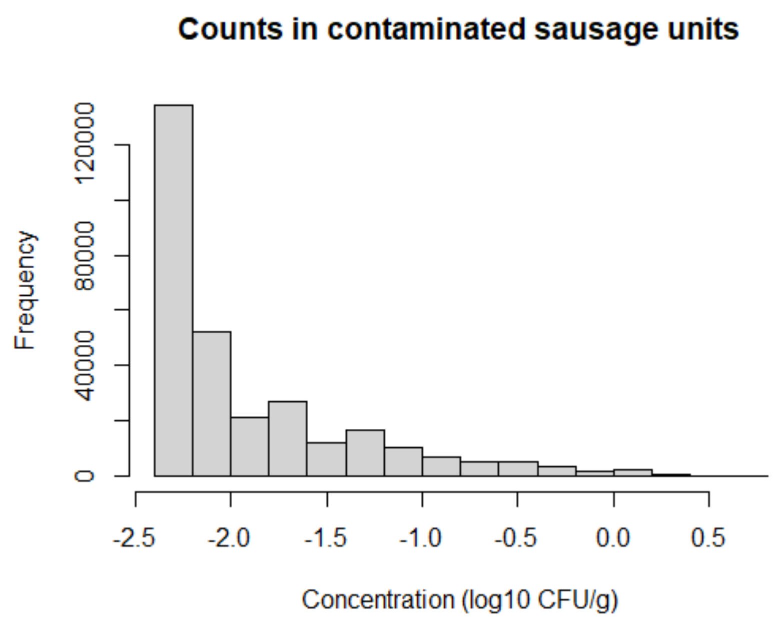
Merguez sausages

- Baseline (P=0.20)



Merguez sausages

- Optimised starter cultures (P=0.02)



- The best intervention strategies could be ranked according to effectiveness for most of the food products

5. Process risk models

Example: *S. aureus* in Portuguese raw milk cheeses

Scenario	Bulk (log CFU/g)	Log10_intervention	μ_ref_mean	LAB_0 (log CFU/g)	Concentration (median) (log CFU/g)	% Reduction
Baseline	N(-2.0, 0.1)	0	0.78	Pert(4.0, 4.5, 6.0)	3.799 (3.264 – 4.385)	-
#1: Addition of 1.0% spearmint extract powder to curd	N(-2.0, 0.1)	Pert(0.3, 0.8, 1.5)	0.78	Pert(4.0, 4.5, 6.0)	3.183 (2.556 – 3.800)	16%
#2: Thermisation of goat's raw milk	N(-3.5, 0.1)	0	0.78	Pert(4.0, 4.5, 6.0)	2.736 (2.211 – 3.231)	28%
#3: Use of ad-hoc starter culture	N(-2.0, 0.1)	0	0.70	Pert(7.0, 8.2, 9.0)	-0.193 (-0.755 - 0.515)	**105%**
#4: = (#2 & #3)	N(-3.5, 0.1)	0	0.70	Pert(7.0, 8.2, 9.0)	-1.097 (-1.495 - -0.607)	**130%**

The ArtiSaneFood free tool

✓ The concept: To bring together all results allowing producers to store information/data of their processes and evaluate their safety

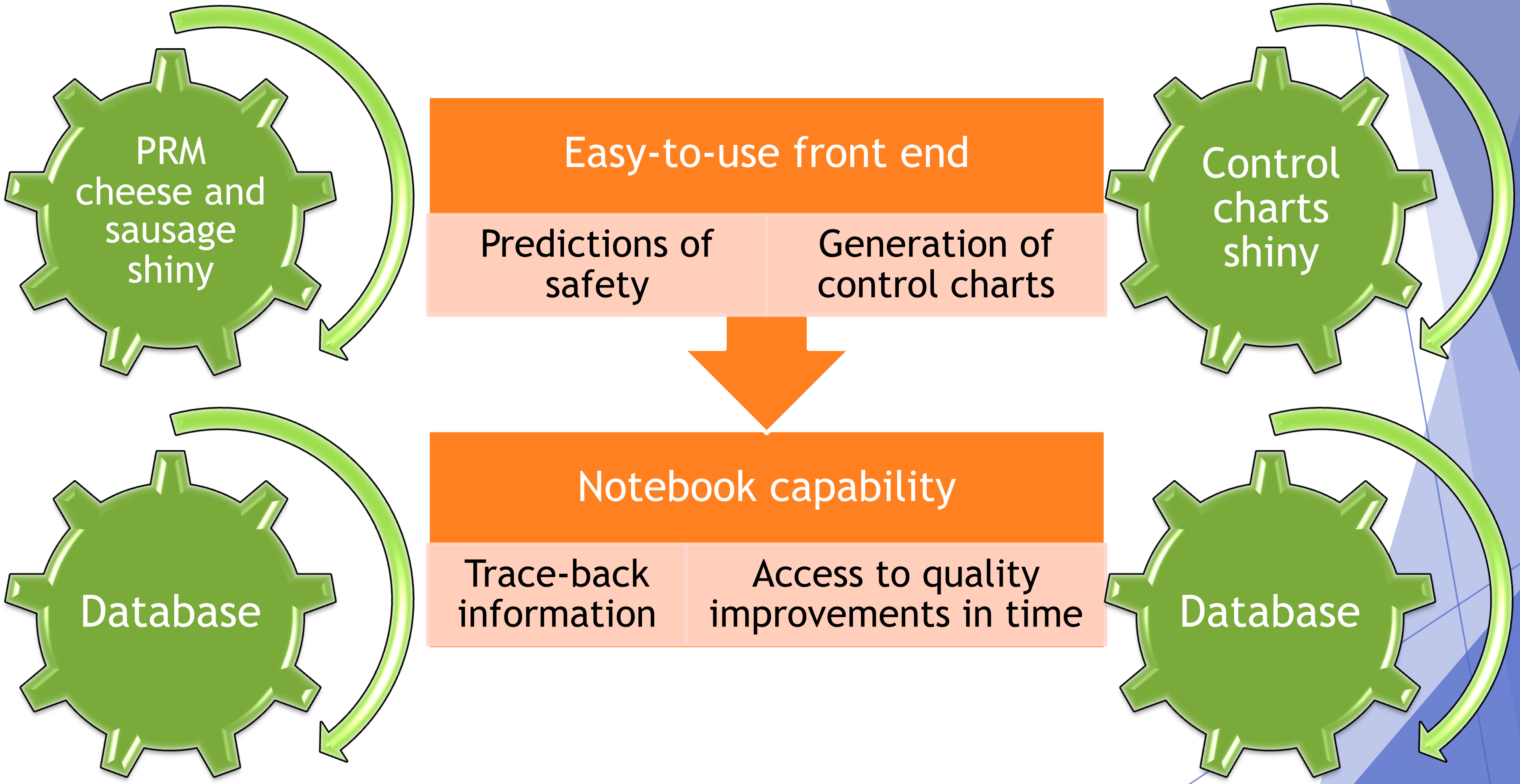
Easy-to-use front end

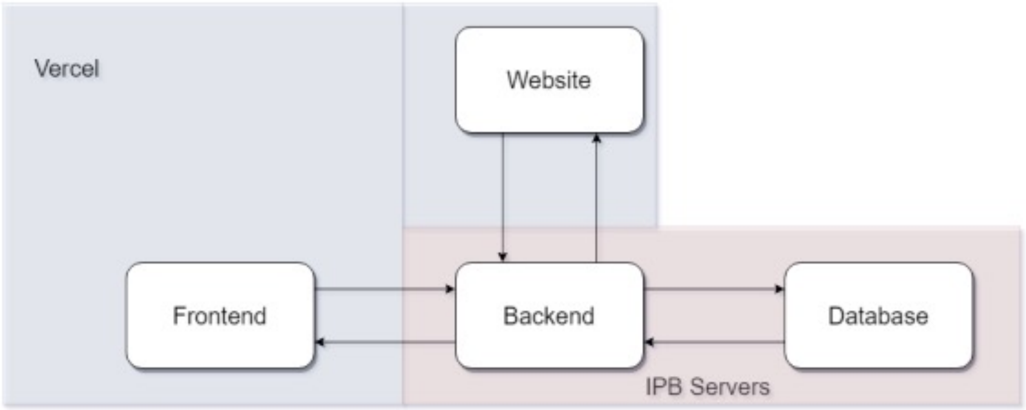
- Predictions of safety
- Generation of control charts

Notebook capability

- Trace-back information
- Access to quality improvements in time

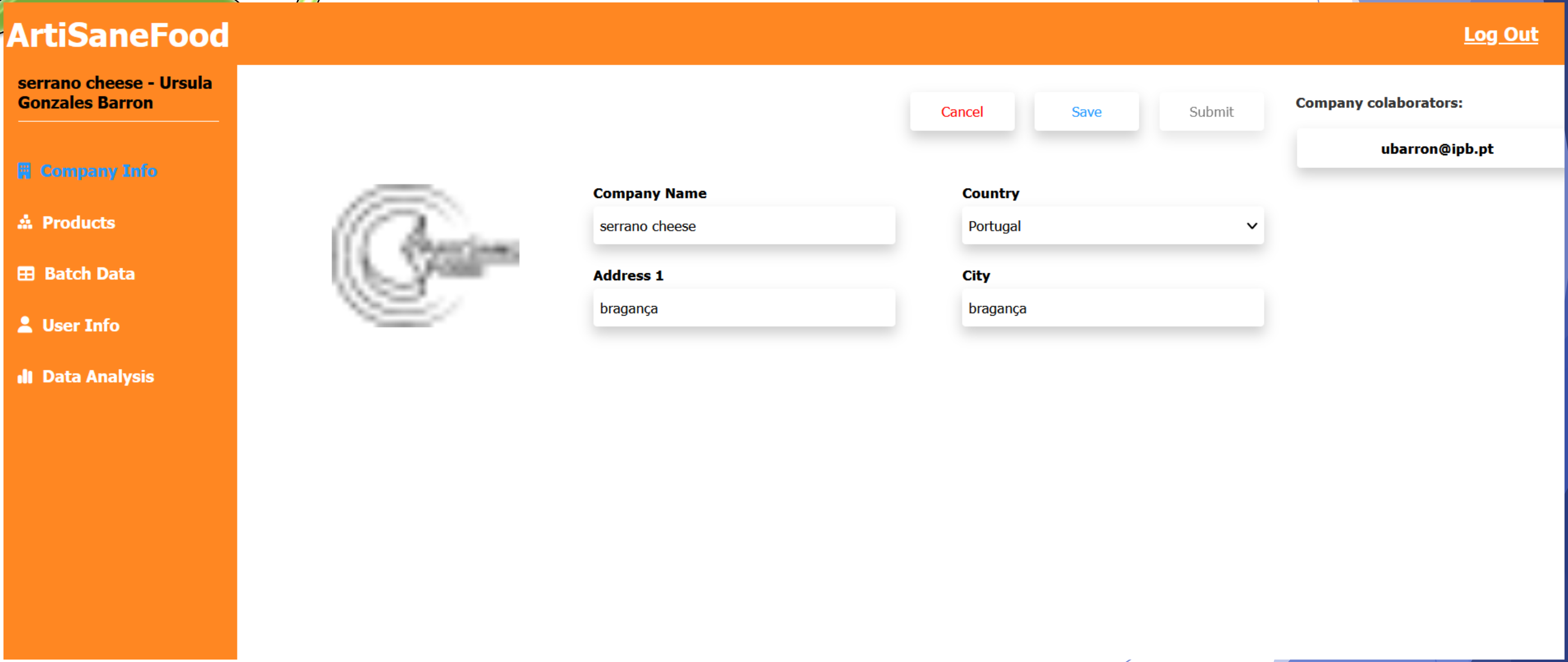
The ArtiSaneFood free tool



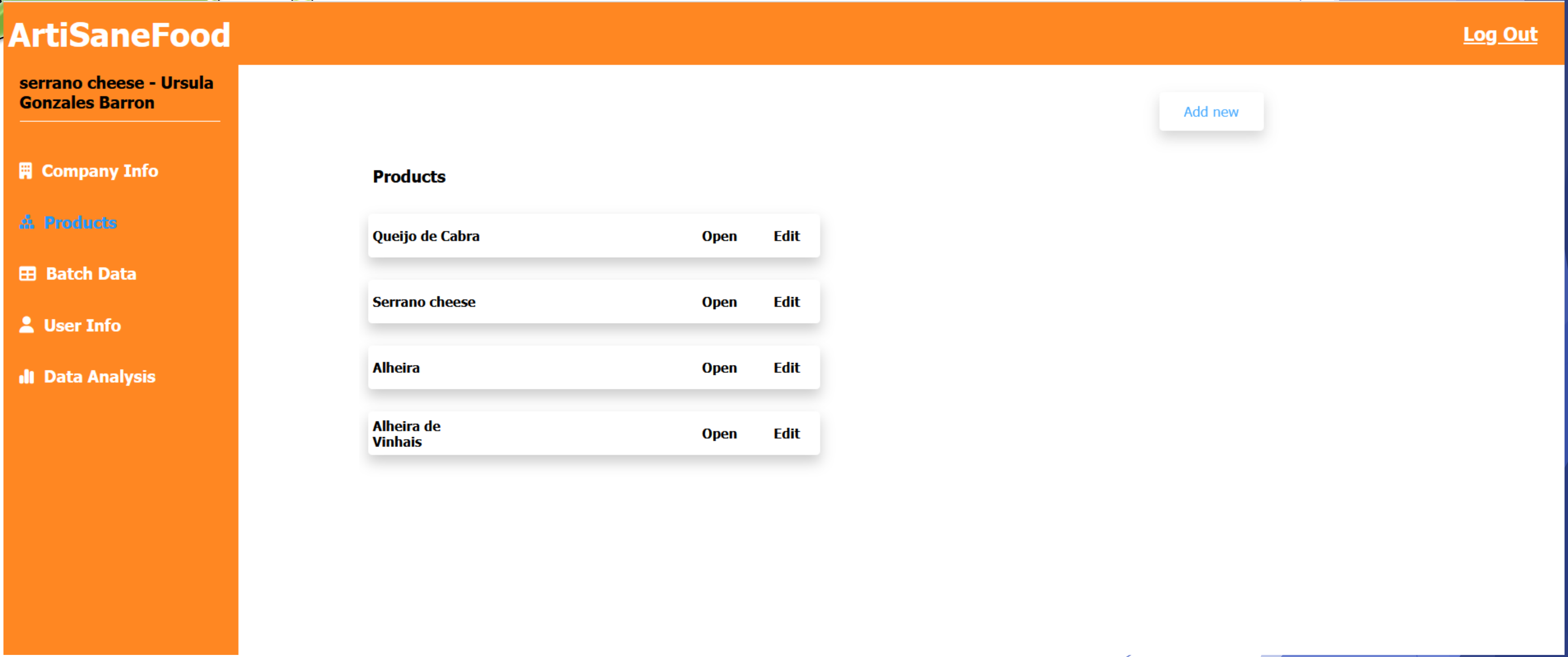


- Producers can introduce their own data from monitoring or controls of the end product
  - Create a company
  - Register members of the company
  - Associate products to the company
  - Insert data on a lot basis for analysis of microbial and physicochemical attributes for their foods

Database


ArtiSaneFood
Log Out
serrano cheese - Ursula Gonzales Barron
Company Info
Products
Batch Data
User Info
Data Analysis
Cancel
Save
Submit
Company colaborators:
ubarron@ipb.pt
Company Name
serrano cheese
Country
Portugal
Address 1
bragança
City
bragança

Database


ArtiSaneFood
Log Out
serrano cheese - Ursula Gonzales Barron
Company Info
Products
Batch Data
User Info
Data Analysis
Add new
Products
Queijo de Cabra
Open
Edit
Serrano cheese
Open
Edit
Alheira
Open
Edit
Alheira de Vinhais
Open
Edit

Database

ArtiSaneFood — Log Out

serrano cheese - Ursula Gonzales Barron

- Company Info
- Products
- Batch Data
- User Info
- Data Analysis

Export Data | New Batch

	Product	Batch ID	Data Type	Production Date	Insertion Date	
0	Serrano cheese	Batch1	Individual	2022-10-31	26/07/2023	···
1	Serrano cheese	Batch2	Individual	2022-11-16	04/02/2023	···
2	Serrano cheese	Batch3	Mean	2022-11-14	17/11/2022	···
3	Serrano cheese	Batch4	Mean	2022-11-16	18/11/2022	···
4	Serrano cheese	Batch 3	Mean	2023-01-20	06/02/2023	···
5	Serrano cheese	C1	Individual	16/11/2020	28/07/2023	···
6	Serrano cheese	C2	Individual	23/11/2020	28/07/2023	···
7	Serrano cheese	C3	Individual	02/12/2020	28/07/2023	···
8	Serrano cheese	C4	Individual	22/03/2021	28/07/2023	···

1/1

Table Filters:

Product Name:

Serrano cheese

Production Date:

From:

dd / mm / yyyy

To:

dd / mm / yyyy

Search

Database

General Data

Batch ID	Batch1
Product	Serrano cheese
Batch Size	100
Number of samples	2
Trial	Yes
Production Date	2022-10-31
Insertion Date	09/06/2023

Samples

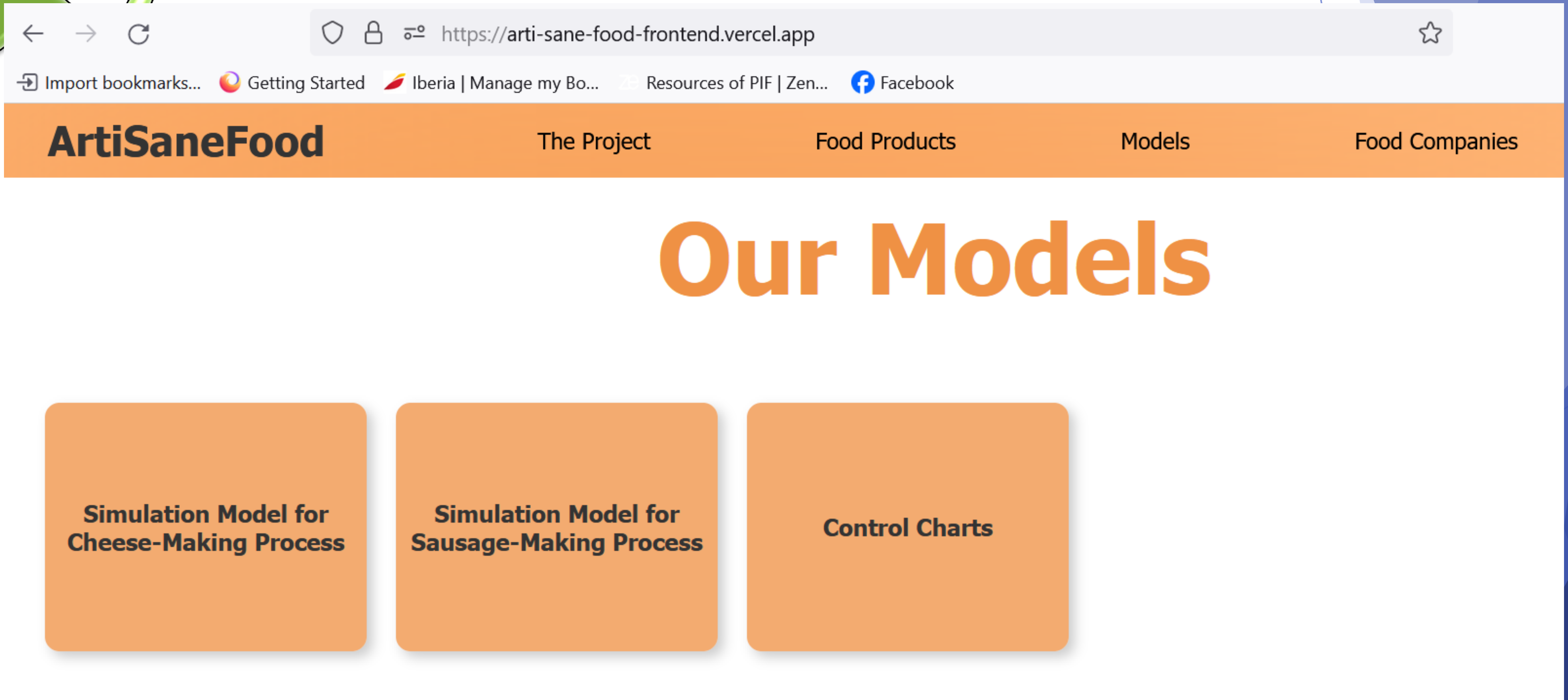
Sample 1 Sample 2

Microbiology Nutritional

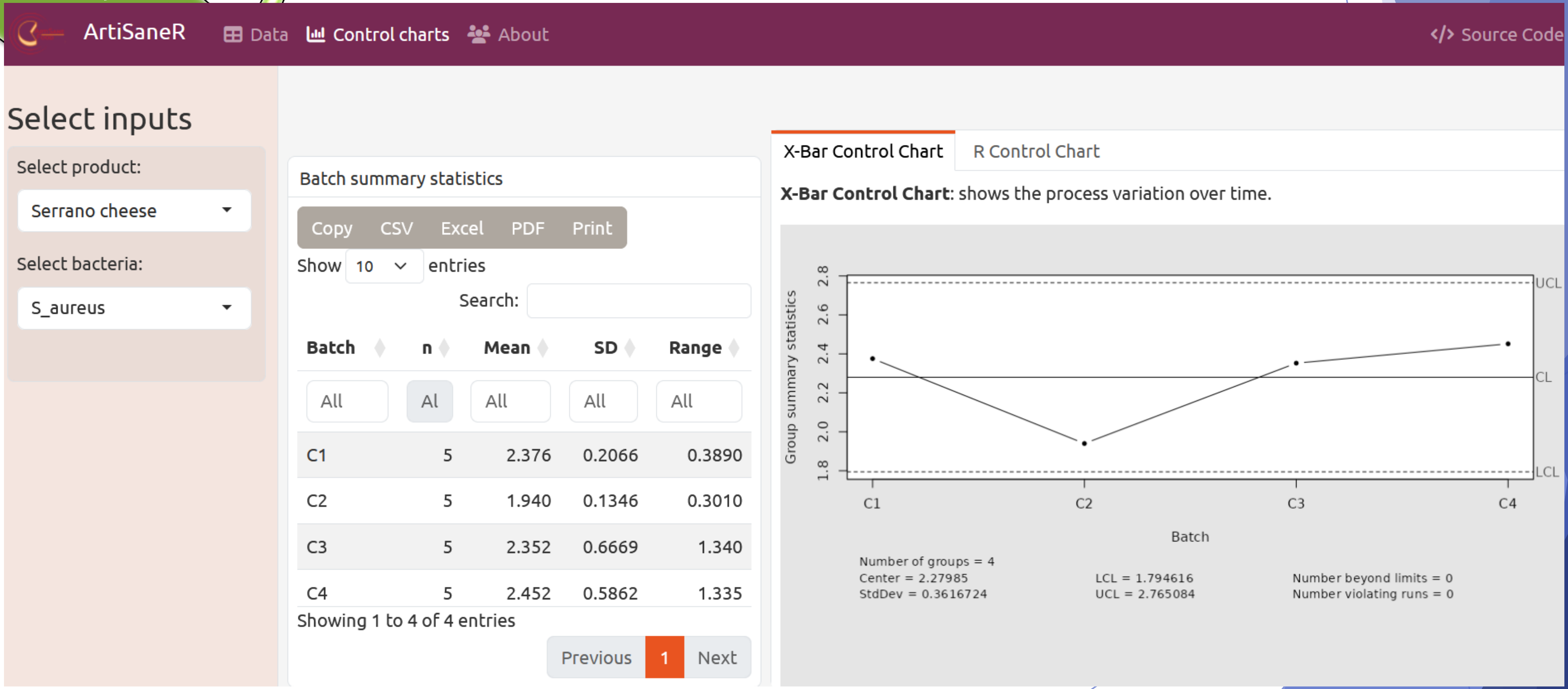
Bacteria	Value	Units
Mesophiles	3.4	(log CFU/g)
LAB	2.1	(log CFU/g)
Coliforms	4.3	(log CFU/g)
E. coli	0.6	(log CFU/g)
Staphylococci	-	(log CFU/g)
Bacillus cereus	-	(log CFU/g)
S. aureus	-	(log CFU/g)
L. monocytogenes	-	(log CFU/g)

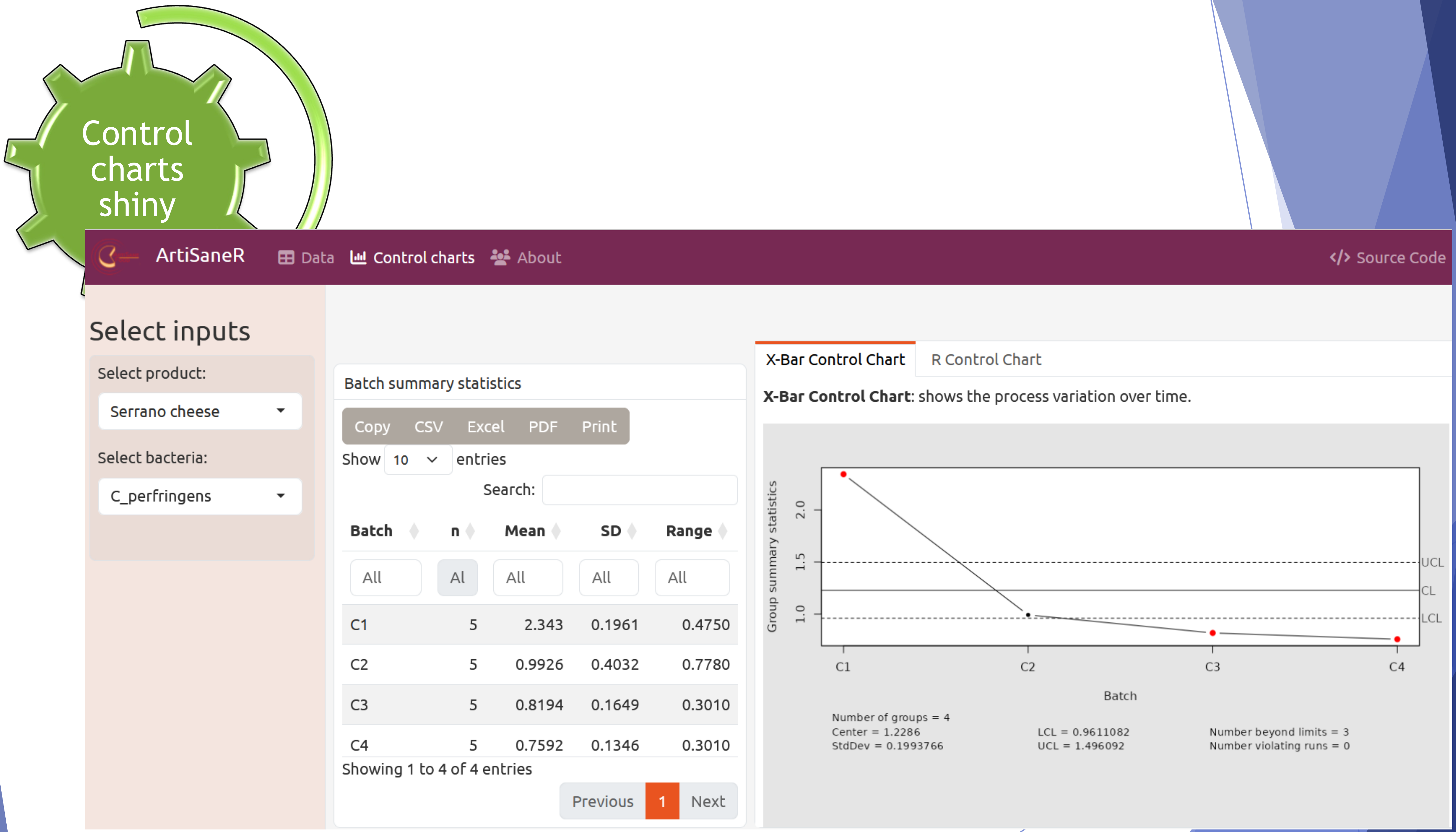
Bacteria	Detected
Salmonella	0
Listeria	1

Control charts shiny



Control charts shiny




Control charts shiny
ArtiSaneR
Data
Control charts
About
Source Code
Select inputs
Select product:
Serrano cheese
Select bacteria:
C_perfringens
Batch summary statistics
Copy CSV Excel PDF Print
Show 10 entries
Search:
Batch n Mean SD Range
C1 5 2.343 0.1961 0.4750
C2 5 0.9926 0.4032 0.7780
C3 5 0.8194 0.1649 0.3010
C4 5 0.7592 0.1346 0.3010
Showing 1 to 4 of 4 entries
Previous 1 Next
X-Bar Control Chart
R Control Chart
X-Bar Control Chart: shows the process variation over time.
Group summary statistics
Batch
UCL
CL
LCL
Number of groups = 4
Center = 1.2286
StdDev = 0.1993766
LCL = 0.9611082
UCL = 1.496092
Number beyond limits = 3
Number violating runs = 0

Control charts shiny

ArtiSaneR   Data   Control charts   About   </> Source Code

Select inputs

Select product:

Merguez

Select bacteria:

Mesophiles

Batch summary statistics

Copy   CSV   Excel   PDF   Print

Show 10 entries

Search:

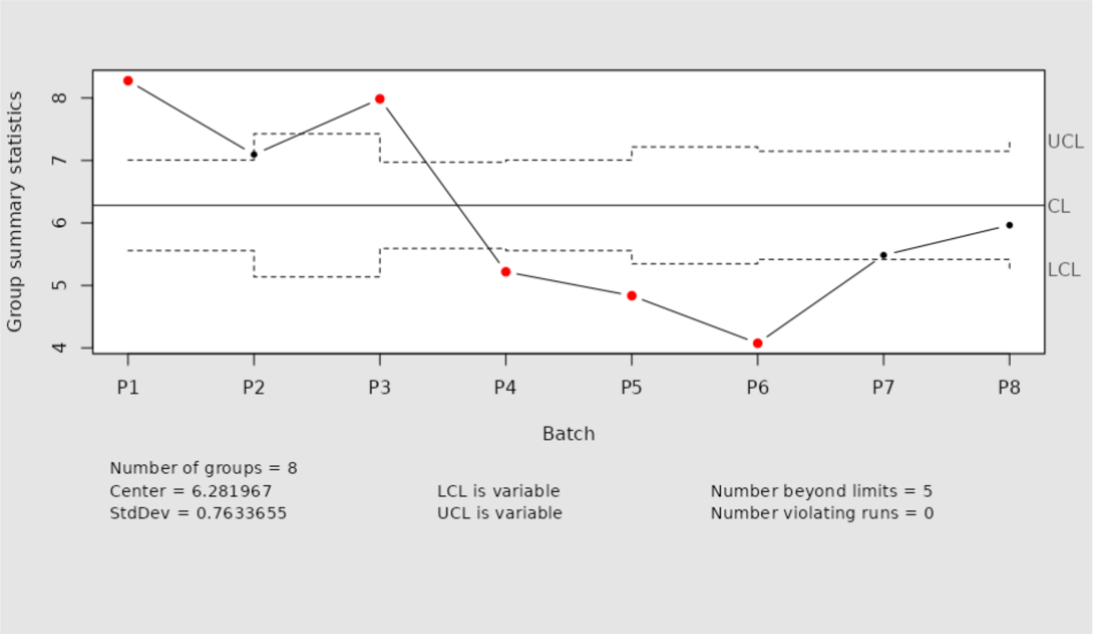
Batch	n	Mean	SD	Range
All	Al	All	All	All
P1	10	8.277	0.2559	0.7608
P2	4	7.094	1.641	3.356
P3	11	7.985	0.6208	1.652
P4	10	5.219	0.4720	1.215

Showing 1 to 8 of 8 entries

Previous 1 Next

X-Bar Control Chart   R Control Chart

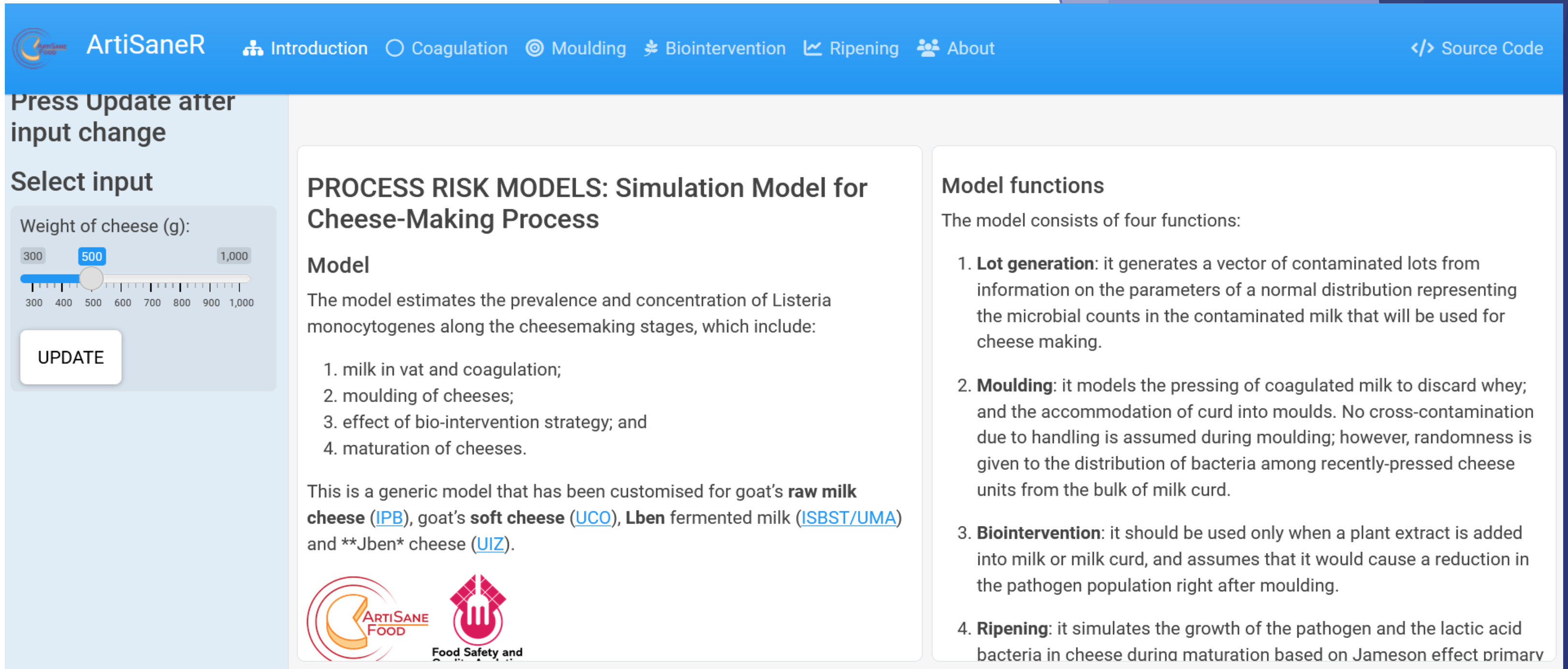
X-Bar Control Chart: shows the process variation over time.

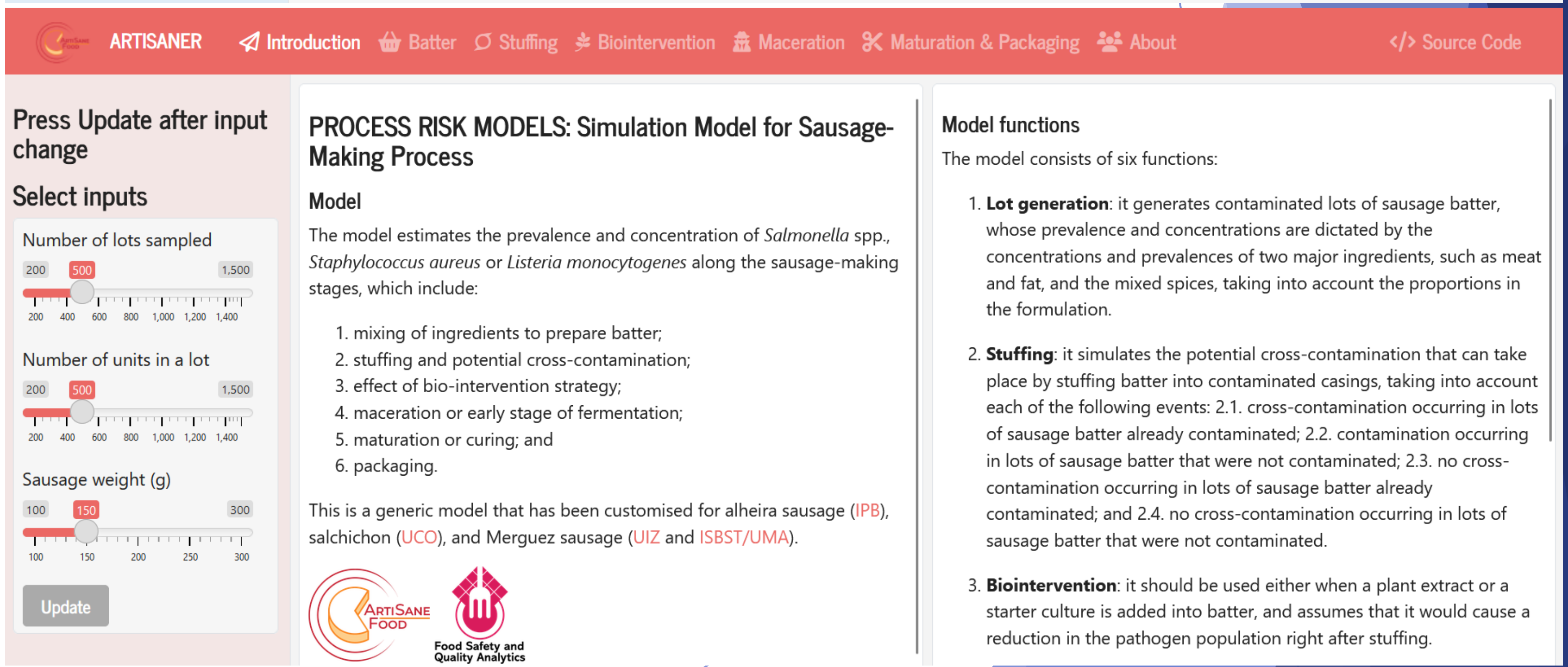


Open the link:

https://arti-sane-food-frontend.vercel.app/

And try by yourselves!





ARTISANER | Introduction | Batter | Stuffing | Biointervention | Maceration | Maturation & Packaging | About | Source Code

Select inputs

Set a random seed

100 (range 100–199)

Prevalence in main ingredient 1

0.4 (range 0–1)

Mean contamination in main ingredient 1 (log10 CFU/g)

2.6 (range -3–3)

St. dev. in main ingredient 1 (log10 CFU/g)

0.66 (range 0–2)

Proportion of main ingredient 1 (%)

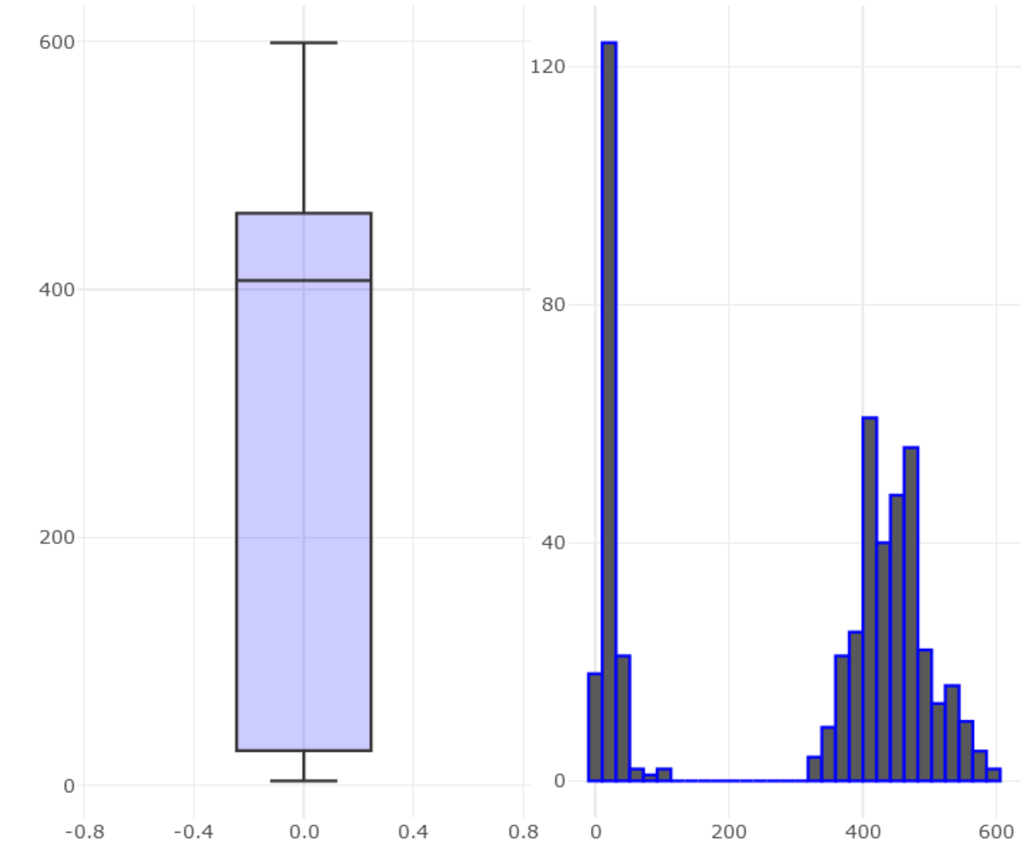
Variability of contamination in bulk batter

```
Prevalence of contaminated lots
[1] 0.6167
```

Summary statistics

	Statistics	Counts (CFU/g)	Counts (log10 CFU/g)
1	Minimum	3.548	0.5499
2	pct 2.5th	3.616	0.5582
3	Mean	304.2	2.190
4	Median	407.0	2.610
5	pct 97.5th	549.0	2.740
6	Maximum	598.9	2.777

Counts distribution (CFU/g) | ECDF



ARTISANER Introduction Batter Stuffing Biointervention Maceration Maturation & Packaging About </> Source Code

Select inputs

Set a random seed

200 299

200 210 220 230 240 250 260 270 280 290 299

Probability of having casings contaminated on a lot basis

0 0.2 1

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Numbers of microbes on the internal surface of a single casing (CFU)

0 20 100

0 10 20 30 40 50 60 70 80 90 100

Dispersion factor of the Beta distribution

0 1.5 5

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Update

Variability of mean contamination between lots after stuffing

```
Prevalence of contaminated lots after stuffing
[1] 0.69336
```

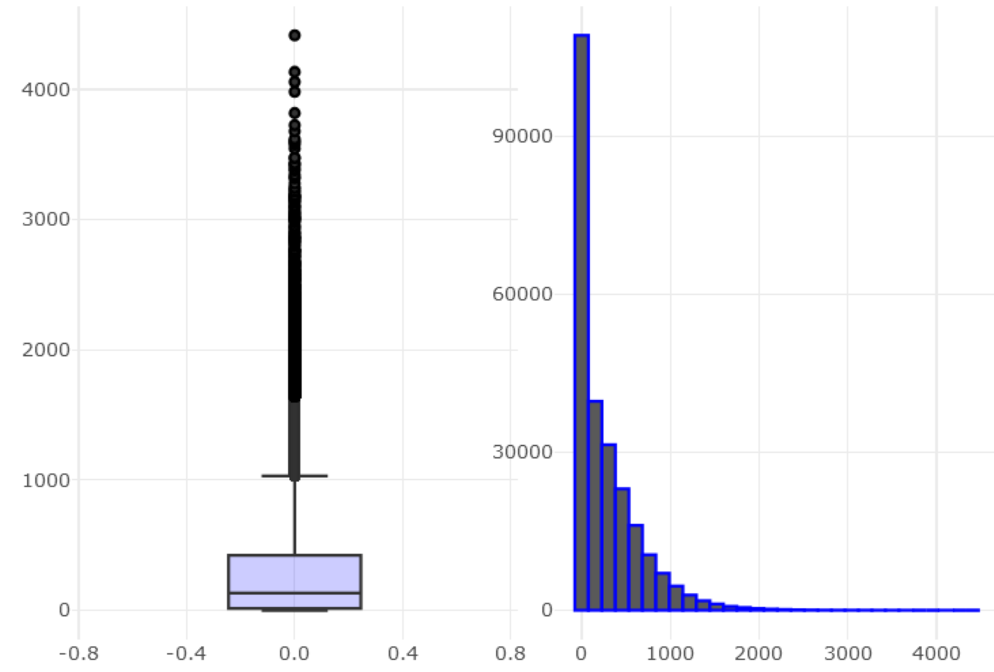
Summary statistics | Counts distribution (CFU/g)

	Statistics	Counts (CFU/g)	Counts (log10 CFU/g)
1	Minimum	0.1308	-0.8833
2	pct 2.5th	0.1327	-0.8771
3	Mean	275.3	1.889
4	Median	397.6	2.599
5	pct 97.5th	548.8	2.739
6	Maximum	597.7	2.777

Variability of contaminated sausages after stuffing

```
Prevalence of contaminated sausages after stuffing
[1] 0.6921064
```

Summary statistics | Counts distribution (CFU/g)



ARTISANER | Introduction | Batter | Stuffing | Biointervention | Maceration | Maturation & Packaging | About | Source Code

Select inputs

Set a random seed: 300 (range 300–399)

Minimum log10 reduction: 0 (range 0–5)

Mode log10 reduction: 0 (range 0–5)

Maximum log10 reduction: 0 (range 0–5)

Update

Variability of mean contamination between lots before maceration

```
prevalence of contaminated lots before maceration
[1] 0.69336
```

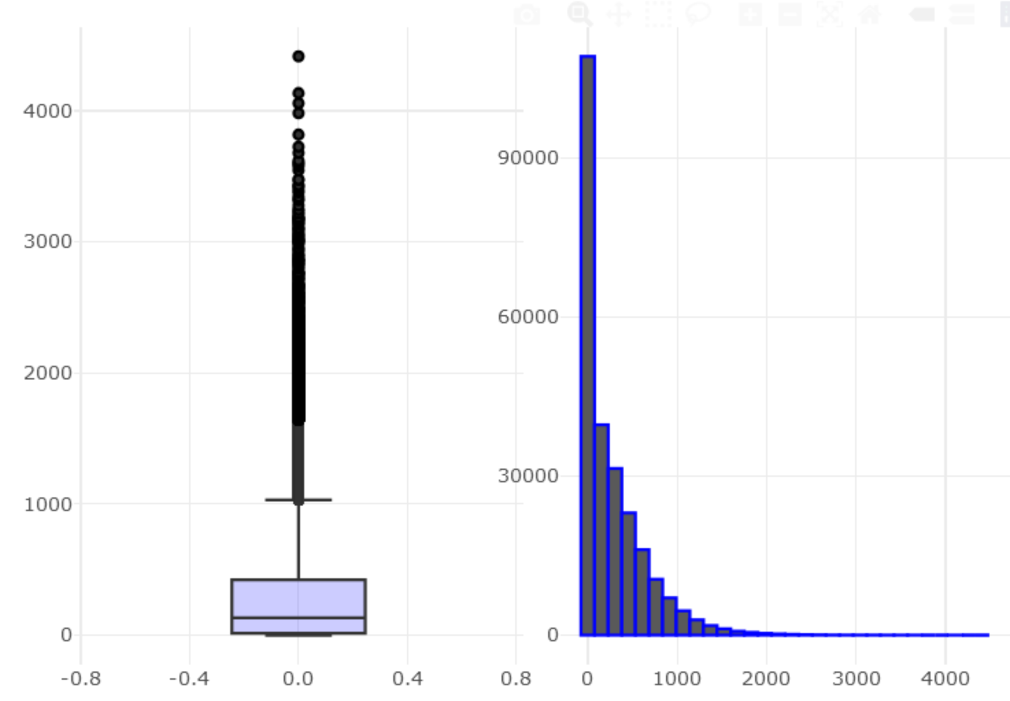
Summary statistics | Counts distribution (CFU/g)

	Statistics	Counts (CFU/g)	Counts (log10 CFU/g)
1	Minimum	0.1308	-0.8833
2	pct 2.5th	0.1327	-0.8771
3	Mean	275.3	1.889
4	Median	397.6	2.599
5	pct 97.5th	548.8	2.739
6	Maximum	597.7	2.777

Variability of contaminated sausages before maceration

```
Prevalence of contaminated sausages before maceration
[1] 0.6921064
```

Summary statistics | Counts distribution (CFU/g)



ARTISANER | Introduction | Batter | Stuffing | Biointervention | Maceration | Maturation & Packaging | About | </> Source Code

Select inputs

Set a random seed: 400 (range 400–499)

Maximum population density (log10 CFU/g): 7.5 (range 4–10)

Mean exponential growth rate at 5 ºC (1/h): 0.036 (range 0.01–1.2)

St. error of the mean exponential growth rate at 5 ºC (1/h): 0.004 (range 0–1.2)

Nominal minimum

Variability of mean contamination between lots after maceration

```
Prevalence of contaminated lots after maceration
[1] 0.69336
```

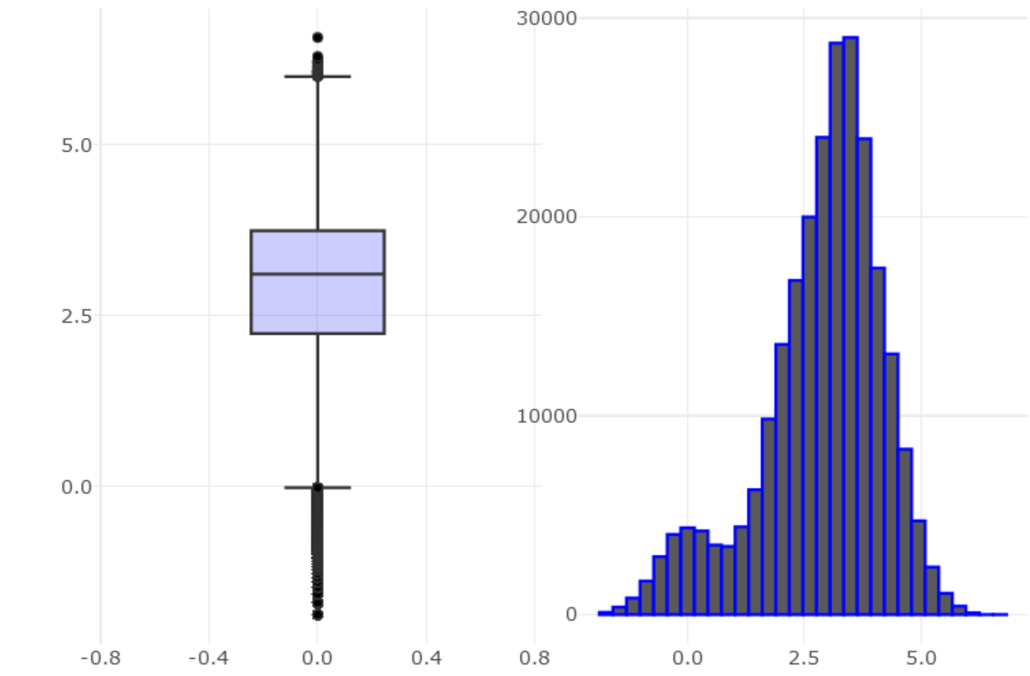
Summary statistics | Counts distribution (log10 CFU/g)

	Statistics	Counts (CFU/g)	Counts (log10 CFU/g)
1	Minimum	0.2589	-0.5869
2	pct 2.5th	0.6814	-0.1666
3	Mean	1.101e+4	3.025
4	Median	1,995	3.300
5	pct 97.5th	8.056e+4	4.906
6	Maximum	4.793e+5	5.681

Variability of contaminated sausages after maceration

```
Prevalence of contaminated sausages after maceration
[1] 0.6921064
```

Summary statistics | Counts distribution (log10 CFU/g)



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Select inputs

Set a random seed: 500 (range 500–599)

Sausages pH at the start of maturation: 5.6 (range 3.5–7)

Maturation time at low temperature (h): 120 (range 24–240)

Log10 of reference D (day) at pHref=7.0: 1.04 (range 0–3)

St. dev. of log10 of reference

Variability of mean contamination between lots

```
Prevalence of contaminated lots
[1] 0.69336
```

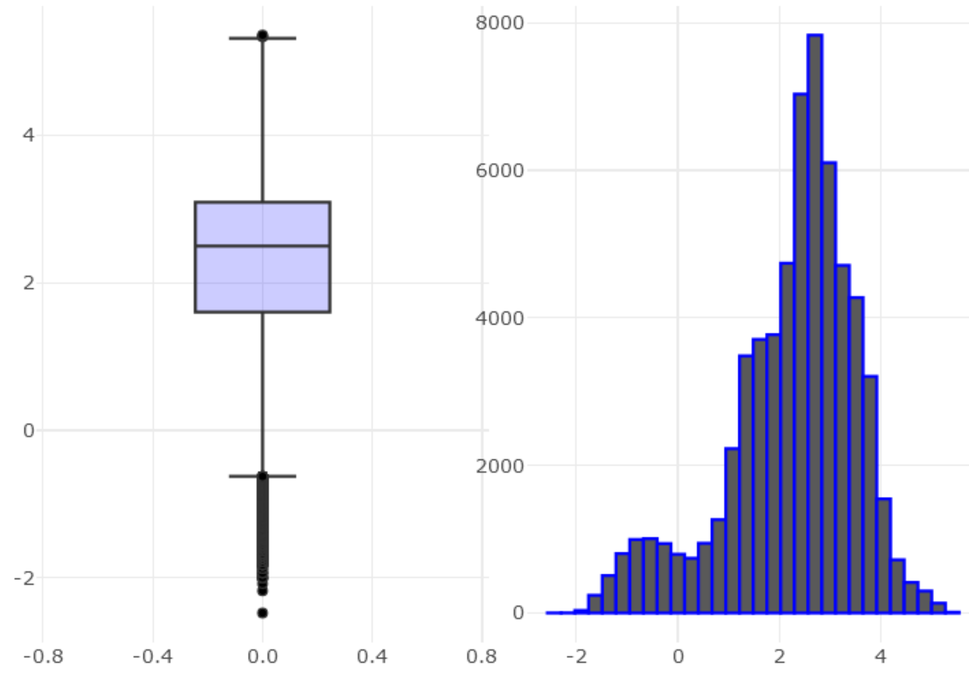
Summary statistics | Counts distribution (log10 CFU/g)

	Statistics	Counts (CFU/g)	Counts (log10 CFU/g)
1	Minimum	0.02901	-1.537
2	pct 2.5th	0.1179	-0.9285
3	Mean	2,299	2.292
4	Median	350.4	2.545
5	pct 97.5th	1.352e+4	4.131
6	Maximum	1.067e+5	5.028

Variability of contamination in the packs

```
Prevalence of contaminated packs
[1] 0.69336
```

Summary statistics | Counts distribution (log10 CFU/g)



Conclusions

At producer's level

- Solved processing problems affecting the safety of traditional foods to regional producers (x15)

At scientific level

- New approaches for estimating the kinetic parameters of patho-gens in fermented food
- The efficiency of many bio-preservation strategies have been characterised

At the technical level

- Project's results are contained in the free online ArtiSaneFood decision-support tool

Sustainability

- ArtiSaneR will evolve to be decision-making tool by incorporating AI applications based on ML

ESTIG/IPB BRAGANÇA, PT
INTERNATIONAL CONFERENCE ON SUSTAINABLE FOODS
Achieving the Sustainable Development Goals
July 24 25 2024

ArtiSaneFood – Innovative bio-interventions and risk modelling approaches for ensuring microbial safety and quality of Mediterranean artisanal fermented foods

ARTISANE FOOD

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PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

European Commission

CIMO Centro de Investigação de Montanha

ipb INSTITUTO POLITÉCNICO DE BRAGANÇA