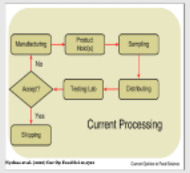
Food Safety and Quality under the Auspices of Data Science
IAFP : Webinar 24/10/2023

George-John NYCHAS
Agricultural University of Athens - Greece



Article 3 &2; 2073/2005:

As necessary, the food business operators responsible for the manufacture of the product shall conduct studies in accordance with **Annex II** in order to investigate compliance with the criteria throughout the shelf-life.

(EC) No 1441/2007 of 5 December 2007 amending Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs

Chapter 2: Process hygiene criteria 2.1 Meat and products thereof

Carcases of cattle, sheep, goats and horses	Aerobic colony count 3,5 to 5,0 log cfu/cm²	Carcases after dressing but before chilling
	Enterobacteriaceae 1,5 to 2,5 log cfu/cm²	

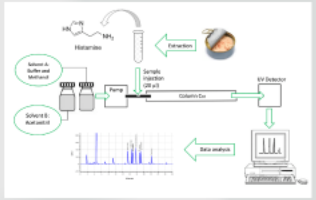
Minced beef: 6 × 10⁵ - 8 × 10⁵ cfu/g — Aerobic colony count: End of the manufacturing process

LEGISLATION

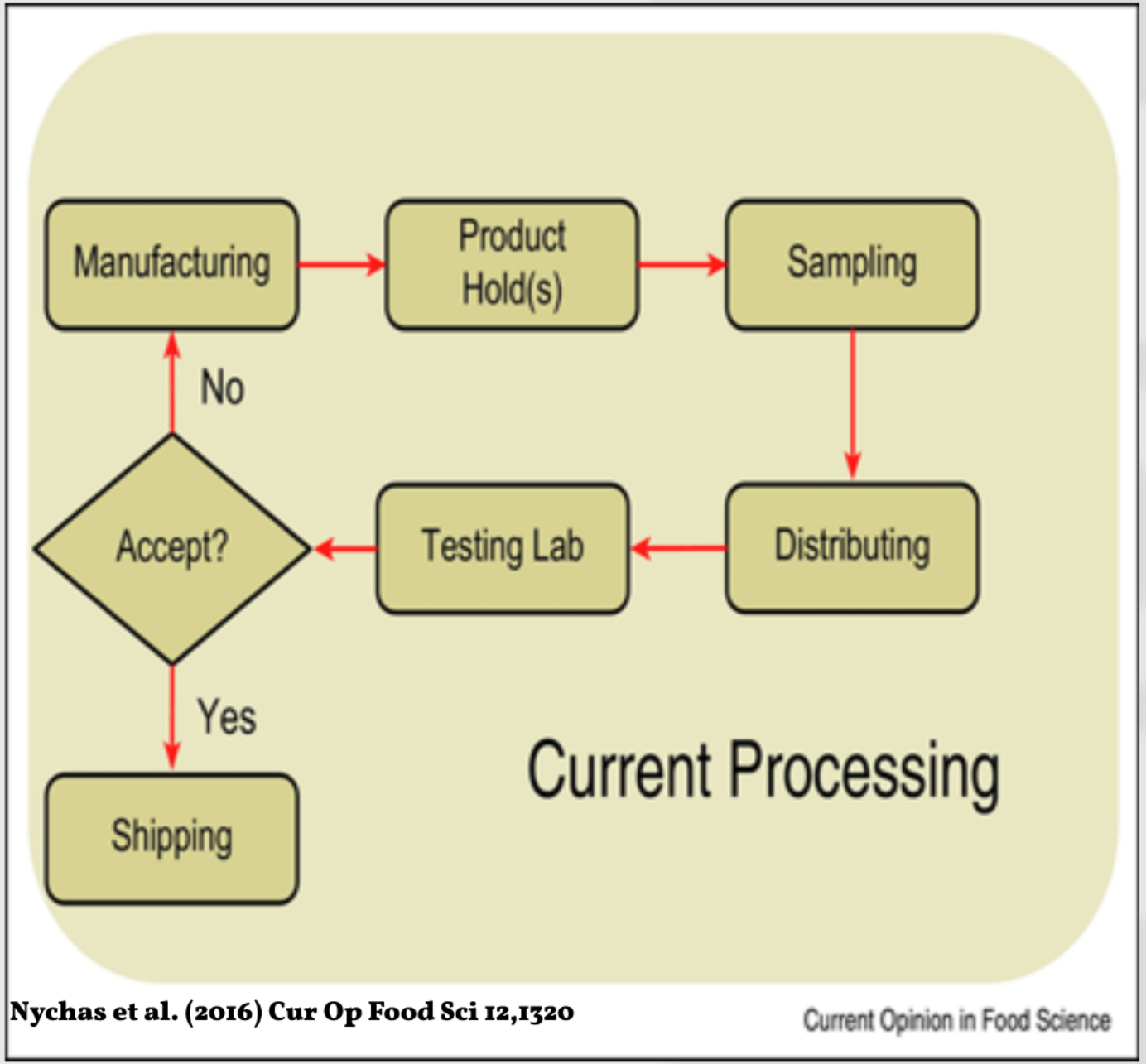
The analysis of THE END / FINISHED product does provide a SINGLE number on which the (whole) production process will be assessed

sample code	Sample description (e.g. pork, chicken, dairy etc.)	Hazards / Quality index	population/concentration (eg. cfu/g, mg/Kg)
K098	cream	*Listeria monocytogenes*	55
B079	fish	biogenic amines	17,35
L345	meat	Enterobacteriaceae	4

Food category	Micro-organism/their toxins, metabolites	Sampling plan (1) n	c	Limits (2) m	M	Analytical reference method (3)	Stage where the criteria applies
1.26. Fishery products which have undergone enzyme maturation treatment in brine, manufactured from fish species associated with a high amount of histidine (4)	Histamine	9	2	200 mg/kg	400 mg/kg	HPLC (4)	Products placed on the market during their shelf-life



Predictive Modeling


Manufacturing
Product Hold(s)
Sampling
No
Accept?
Testing Lab
Distributing
Yes
Shipping
Current Processing
Nychas et al. (2016) Cur Op Food Sci 12,1320
Current Opinion in Food Science

I

(Acts whose publication is obligatory)

COMMISSION REGULATION (EC) No 2073/2005

of 15 November 2005

on microbiological criteria for foodstuffs

(Text with EEA relevance)

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Community,

(4) Microbiological criteria also give guidance on the acceptability of foodstuffs and their manufacturing, handling and distribution processes. The use of microbiological criteria should form an integral part of the implementation of HACCP-based procedures and other hygiene control measures.

(EC) No 1441/2007 of 5 December 2007 amending Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs

Chapter 2. Process hygiene criteria 2.1 Meat and products thereof

Carcases of cattle, sheep, goats and **horses**

Aerobic colony count
3,5 to 5,0 log cfu/cm^2

Enterobacteriaceae
1,5 to 2,5 log cfu/cm^2

Carcases after dressing but before chilling

Minced beef
5×10^5 - 5×10^6 cfu/g

Aerobic colony count
End of the manufacturing process

LEGISLATION

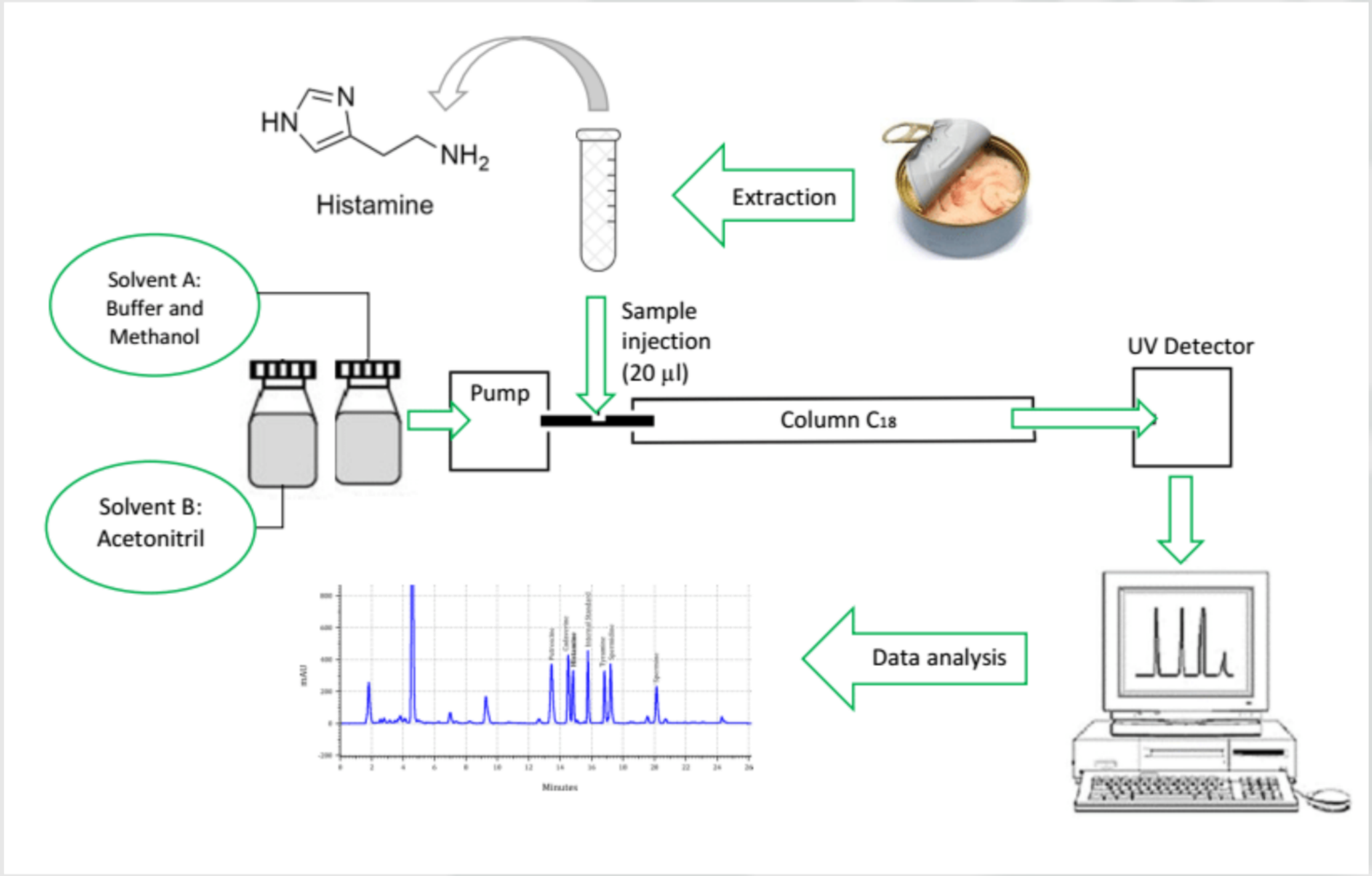
Minced beef
5×10^5 - 5×10^6 cfu/g

Aerobic colony count
End of the manufacturing process

LEGISLATION

Food category	Micro-organisms/their toxins, metabolites	Sampling-plan (1)		Limits (2)		Analytical reference method (3)	Stage where the criterion applies
		n	c	m	M		
1.26. Fishery products which have undergone enzyme maturation treatment in brine, manufactured from fish species associated with a high amount of histidine (16)	Histamine	9	2	200 mg/kg	400 mg/kg	HPLC (18)	Products placed on the market during their shelf-life

L 338/12 EN


HN
N
NH2
Histamine
Extraction
Solvent A:
Buffer and
Methanol
Solvent B:
Acetonitril
Pump
Sample
injection
(20 µl)
Column C18
UV Detector
Data analysis
mAU
Minutes

The analysis of THE END / FINISHED product does provide a SINGLE number on which the (whole) production process will be assessed

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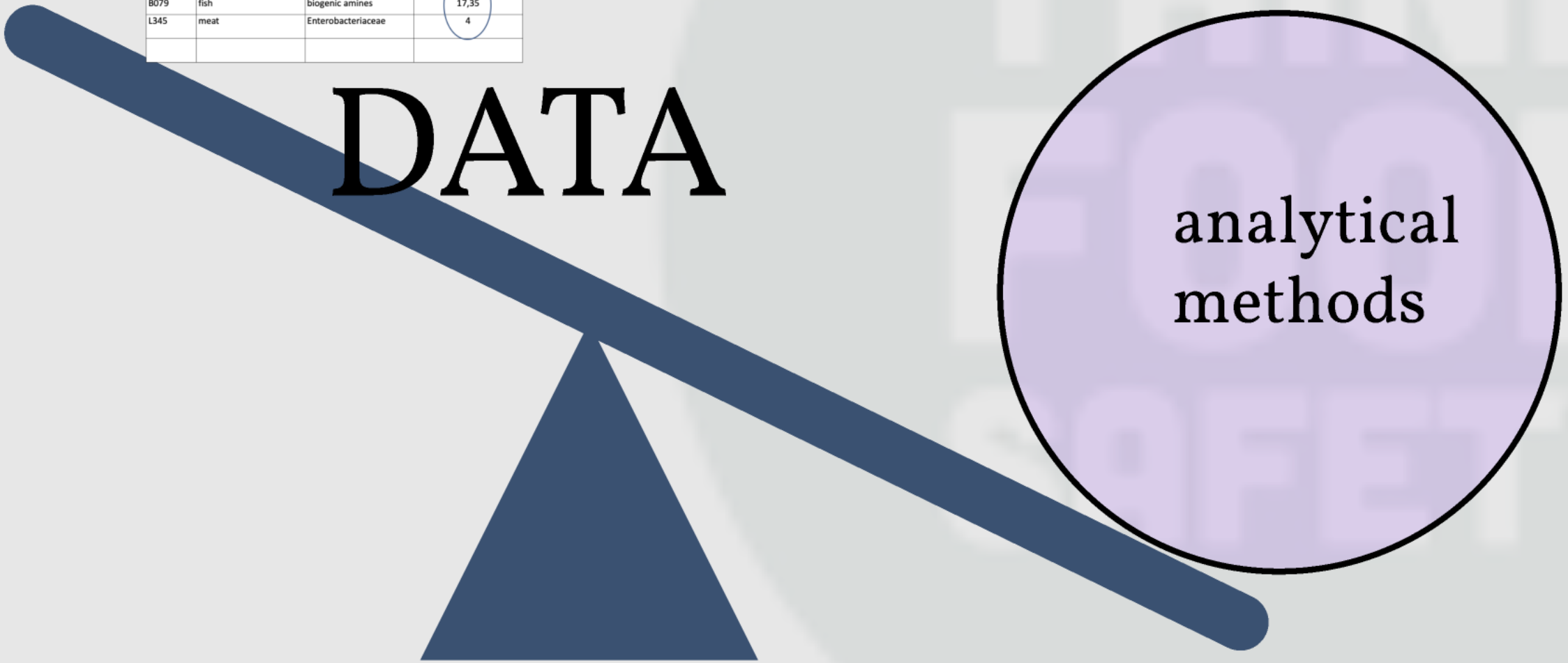


Article 3 &2; 2073/2005:

As necessary, the food business operators responsible for the manufacture of the product shall conduct studies in accordance with **Annex II** in order to investigate compliance with the criteria throughout the shelf-life.


The role of Predictive Modelling in Food Safety & Quality
Predictive software
Computing
Mathematical models
Database / libraries
Outcome's availability; minutes (if initial population of m/o is known)
USST (China)
Microrisk Lab
an online modeling freeware for predictive microbiology
Survival of Lon in Katiki (soft) cheese at different To C
Contribution of individual strains in the cocktail experiments at the end of storage of katiki cheese stored at different temperatures
Failure (T) of models to describe the data at 50 C (but NN)
Failure of the temperature control across the food distribution

The role of Predictive Modeling in Food Safety & Quality

ANNEX II

The studies referred to in Article 3(2) shall include:

— specifications for physico-chemical characteristics of the product, such as pH, aw, salt content, concentration of preservatives and the type of packaging system, taking into account the storage and processing conditions, the possibilities for contamination and the foreseen shelf-life, and

— consultation of available scientific literature and research data regarding the growth and survival characteristics of the micro-organisms of concern.

When necessary on the basis of the above mentioned studies, the food business operator shall conduct additional studies, which may include:

— predictive mathematical modeling established for the food in question, using critical growth or survival factors for the micro-organisms of concern in the product,

— tests to investigate the ability of the appropriately inoculated micro-organism of concern to grow or survive in the product under different reasonably foreseeable storage conditions,

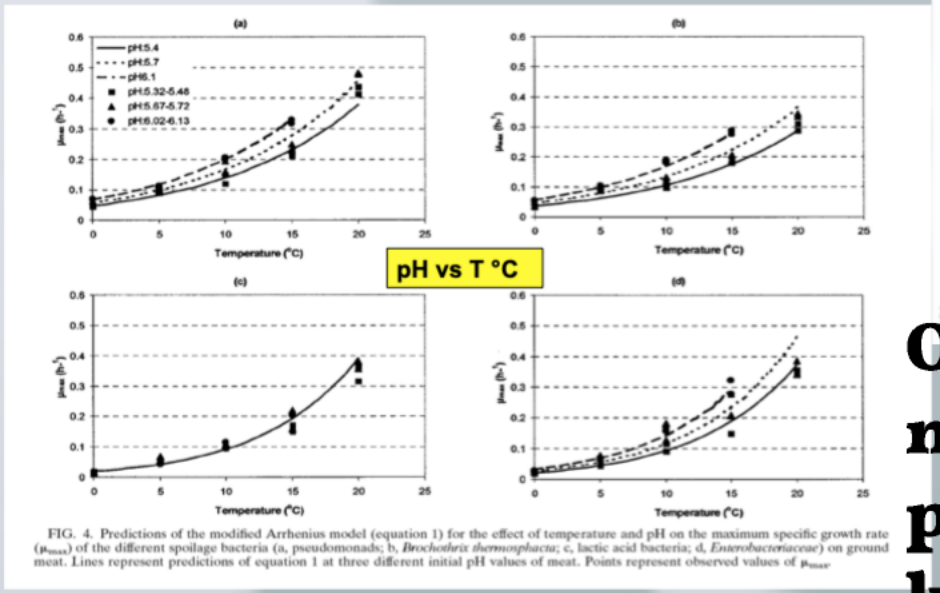
— studies to evaluate the growth or survival of the micro-organisms of concern that may be present in the product during the shelf-life under reasonably foreseeable conditions of distribution, storage and use.

The above mentioned studies shall take into account the inherent variability linked to the product, the microorganisms in question and the processing and storage conditions.

Predictive software

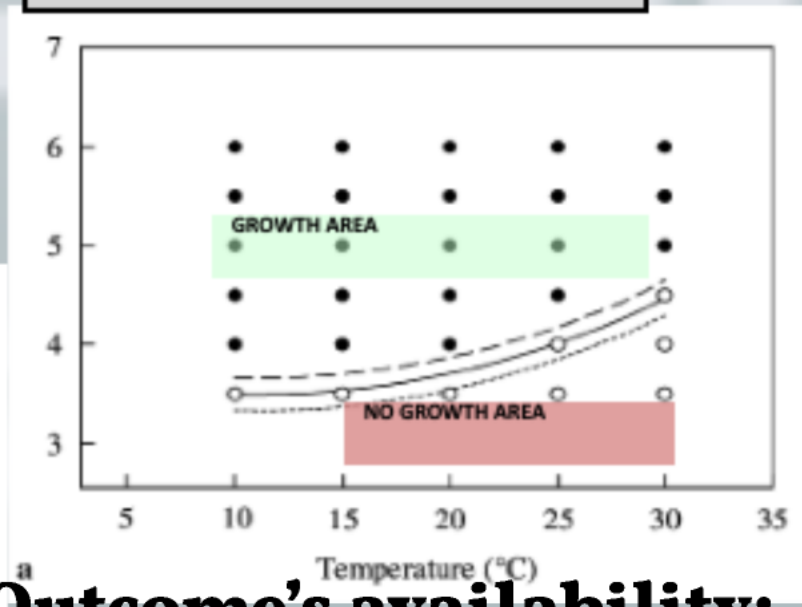
Mathematical models

Database / libraries



pH vs T °C

FIG. 4. Predictions of the modified Arrhenius model (equation 1) for the effect of temperature and pH on the maximum specific growth rate (μ_{max}) of the different spoilage bacteria (a, pseudomonads; b, *Brochothrix thermosphacta*; c, lactic acid bacteria; d, *Enterobacteriaceae*) on ground meat. Lines represent predictions of equation 1 at three different initial pH values of meat. Points represent observed values of μ_{max}



Outcome's availability; minutes (if initial population of m/o is known)

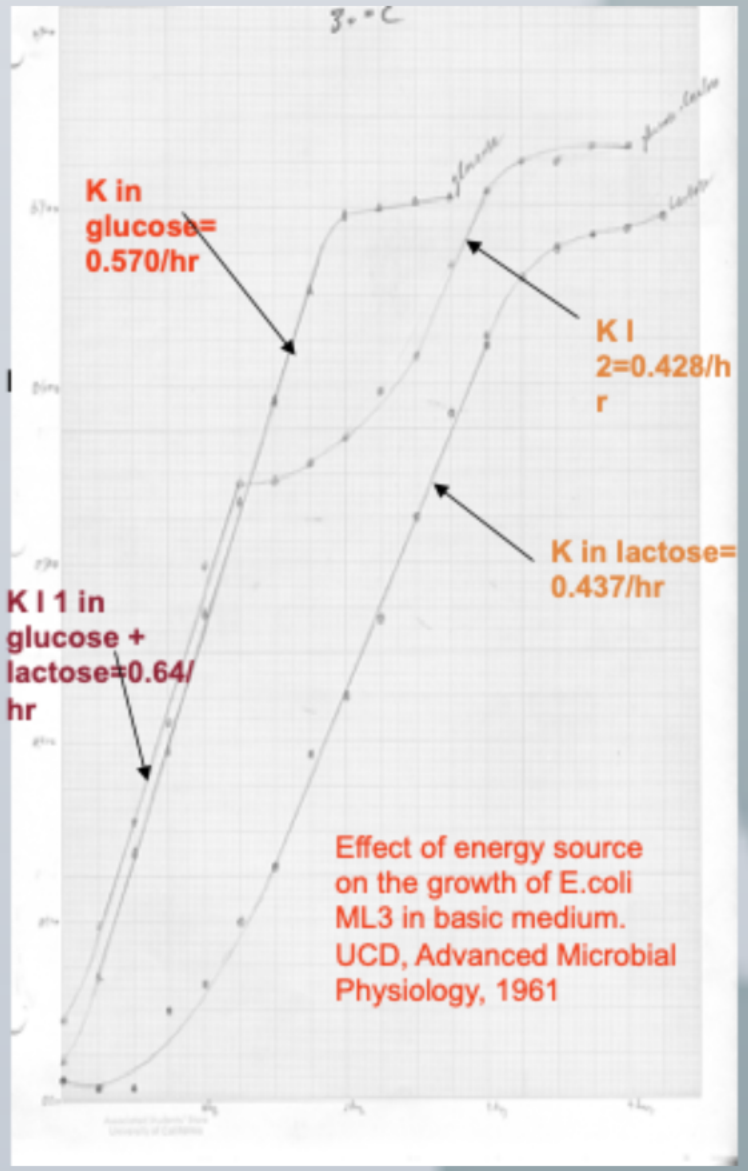


TABLE 1. Specific growth rates of *E. coli* ML3 growing in minimal medium with three different energy sources as determined graphically by TINO`S hand and Baranyi and Roberts (1994).

Source: Advanced Microbial Physiology Laboratory Class. University of California, Davis 1961 (Professors: J. Ingraham, J. Marr, R. Hungate)

Energy source	Determination Method		
	Graphical 1961	Baranyi and Roberts 1994	
	Specific growth rate (1/h)	Specific growth rate (1/h)	Lag phase (h)
Glucose	0.570	0.619	0.088
Lactose	0.437	0.461	0.905
Glucose + Lactose Phase 1	0.640	0.580	0.000
Glucose + Lactose Phase 2	0.428	0.368	0.763


FDA-iRISK
SOFTWARE for PREDICTIVE MICROBIOLOGY & RISK ASSESSMENT
Predictor
FISHMAP
Food spoilage and safety predictor (FSSP)
GroPIN
Dairy Products Safety m
ComBase
Baseline
GInaFiT
Listeria Meat Model
FILTREX
Food spoilage and Safety predictor (FSSP)
PMM
Sym'Previus
MicroHibro
Dairy Products Safety m
Predictor
Listeria Meat Model

Contents lists available at ScienceDirect

Food Microbiology

journal homepage: www.elsevier.com/locate/fm

Software for predictive microbiology and risk assessment: A description and comparison of tools presented at the ICPMF8 Software Fair

Fanny Tenenhaus-Aziza [a], Mariem Ellouze [b, *]

Software	Accessibility	Date of creation	Targeted users	Modeling approach
Baseline	Free, internet access	2012	FBOs, Researchers, Teachers, Students	Deterministic
ComBase	Free, internet access	2004	FBOs, Researchers, Teachers, Students, Government	Deterministic
Dairy Products Safety Predictor	Commercial, internet access	2012	FBOs	Probabilistic
FDA-iRISK	Free, internet access	2012	FBOs, Researchers, Teachers, Students, Government	Probabilistic
FILTREX	Free, downloadable	2013	Researchers, Teachers, Students	Probabilistic
FISHMAP	Free, downloadable	2011	FBOs, Researchers, Teachers, Students, Government	Deterministic
Food Spoilage and Safety Predictor (FSSP)	Free, downloadable	1999	FBOs, Researchers, Teachers, Students, Government	Deterministic
GInaFiT	Free, downloadable	2003	FBOs, Researchers, Teachers, Students, Government	Deterministic
GroPIN	Free, downloadable	2013	FBOs, Researchers, Teachers, Students, Government	Deterministic and probabilistic
Listeria Meat Model	Commercial, downloadable	2012	FBOs, Government	Deterministic
MicroHibro	Free internet access	2011	FBOs, Researchers, Teachers, Students, Government	Probabilistic
MRV, Microbial Responses Viewer	Free internet access	2008	FBOs, Researchers, Teachers, Students, Government	Deterministic
NIZO Premia	Commercial, no internet access	1995	FBOs	Deterministic
PMM-Lab	Free, internet access	2012	Researchers, Teachers, Students, Government	Deterministic
Prediction of Microbial Safety in Meat Products	Free, internet access	2006	FBOs, Researchers, Teachers, Students, Government	Deterministic
Sym'Previus	Commercial, internet access	2003	FBOs, Researchers, Teachers, Students, Government	Deterministic and Probabilistic

USST (China)

Microrisk Lab

an online modeling freeware

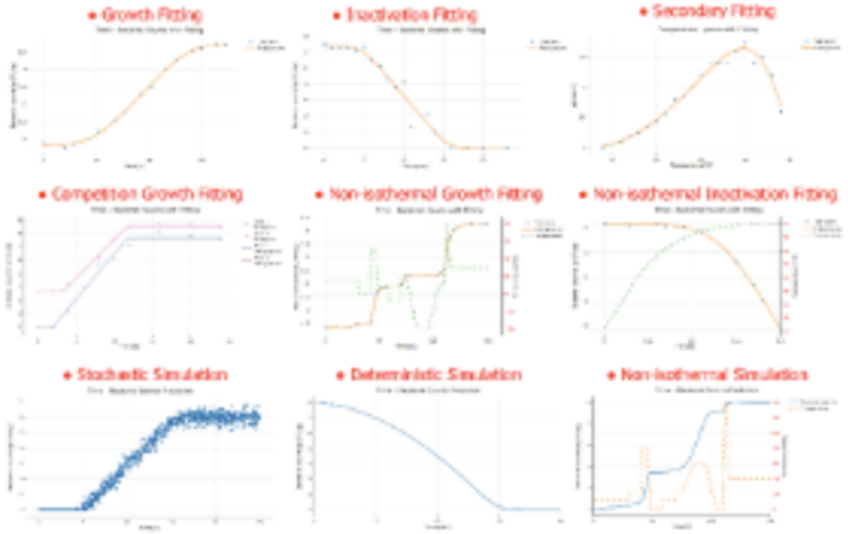
for predictive microbiology

AVAILABLE AT

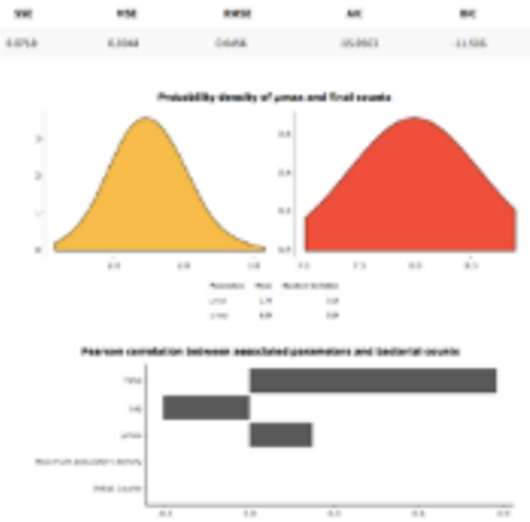
https://www.microrisklab.top/chinese/
https://www.microrisklab.top/english/

★ Numerical and Graphical Interface

★ Integrated Predictive Models

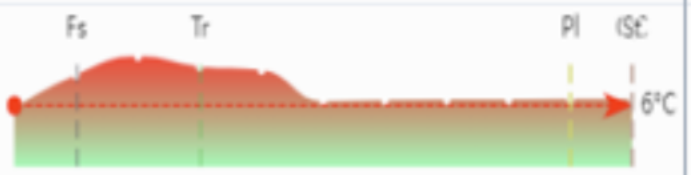
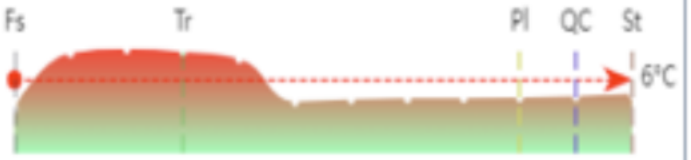


★ Statistical Indicators



Concerns about Predictive models; (i) limited info at primary production (ii) strains vs single sp contamination

Failure of the temperature control across the food distribution

Chart	06:00-06:30	06:30-07:00	07:00-07:30	07:30-08:00	08:00-08:30	08:30-09:00	09:00-09:30	09:30-10:00	10:00-10:30	10:30-11:00	11:00-11:30
	5.81°C	9.00°C	10.84°C	9.78°C	9.47°C	6.41°C	6.50°C	6.56°C	6.59°C	6.63°C	6.66°C
	3.63°C	8.16°C	8.50°C	8.28°C	7.69°C	4.22°C	4.41°C	4.47°C	4.50°C	4.56°C	4.63°C
	6.31°C	10.28°C	11.28°C	8.53°C	8.19°C	7.53°C	7.56°C	7.59°C	7.59°C	7.66°C	7.69°C

Monitoring T C, from Primary Production (fish) to retailers

Harvesting Time
ca 45 min

Temperature
Recording - To C 1

Transportation from
Sea to Land

Transporting Time
ca. 150-180 min

Transportation from Land
to Industry' warehouse

Total Duration
1900 min ca. (1,4 Days)

Temperature
Recording -To C 2

Storage/Quality Assessment/Sorting

Duration Time
ca. 240 min

Packaging (5kg)/ Storage

Duration Time
max 1440 min

Transportation to Distribution
Center / Storage

Transportation time
180 min (3,00H)

Storage - Ready for retailers

Up to 36 Hours;
FiFo(?)

DC + ?

SALES

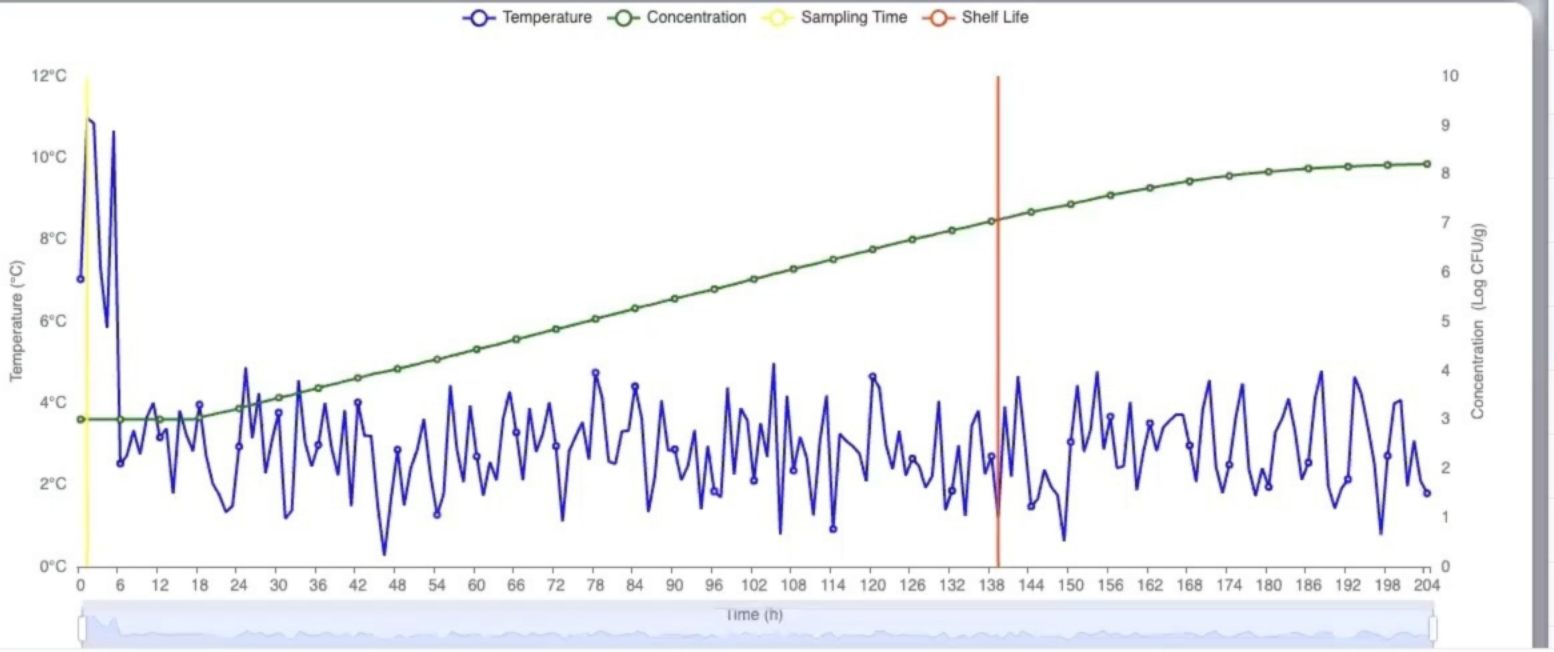
SQP Expiration Date Calculator

The Lot number field is required to calculate results
The Bin EPC input field is optional

Lot Number	Bin EPC	CFU	Sample Hou...	Count	Generator Type	Reference L...
029099		3	1	200	Indicative	999999

Calculate

Shelf Date:: **15/11/2022** Start Date:: **09/11/2022** End Date:: **17/11/2022** Shelf Life:: **139** Sampling Hour:: **1**



Calculation Results

#	T °C	Population
0	7.03°C	3.0
1	10.97°C	3.0
2	10.84°C	3.0
3	7.31°C	3.0
4	5.84°C	3.0
5	10.66°C	3.0
6	2.52°C	3.0
7	2.71°C	3.0
8	3.33°C	3.0
9	2.74°C	3.0
10	3.64°C	3.0
11	4.01°C	3.0

Survival of Lm in Katiki (soft) cheese at different To C

Panagou 2008 JFP; Mataragkas et al 2008 JFP; Kagkli et al AEM 2009

TABLE 1. *Parameter estimation and statistical indices of the different models used for fitting the experimental data*[a]

Model type	$N(0)$ (log CFU g^{-1})	A^b (log CFU g^{-1})	N_{res} (log CFU g^{-1})	k_{max} (day^{-1})	t_s (days)	δ (days)	p	RMSE	R^2	f
rGompertz[c]										
5°C	6.13 ± 0.24	4.21 ± 0.31		0.71 ± 0.14	4.96 ± 1.55			0.371	0.967	4.62[d]
10°C	5.98 ± 0.24	4.35 ± 0.32		0.62 ± 0.11	3.87 ± 0.96			0.334	0.985	1.35
15°C	5.96 ± 0.12	4.34 ± 0.18		0.87 ± 0.09	3.46 ± 0.34			0.249	0.992	0.93
20°C	5.71 ± 0.21	4.38 ± 0.32		1.37 ± 0.32	2.85 ± 0.55			0.422	0.978	2.13
mWeibull[e]										
5°C	6.26 ± 0.25		1.96 ± 0.13			5.81 ± 1.22	1.88 ± 0.67	0.336	0.976	3.78[d]
10°C	6.22 ± 0.23		1.71 ± 0.13			4.38 ± 0.84	1.44 ± 0.27	0.265	0.985	0.85
15°C	6.13 ± 0.13		1.71 ± 0.11			4.10 ± 0.37	1.93 ± 0.25	0.186	0.992	0.52
20°C	6.01 ± 0.25		1.45 ± 0.17			2.87 ± 0.47	1.94 ± 0.43	0.236	0.989	0.67
Geeraerd										
5°C	6.26 ± 0.23		1.88 ± 0.13	0.81 ± 0.14	2.84 ± 1.41			0.301	0.981	3.05[d]
10°C	6.11 ± 0.21		1.69 ± 0.13	1.01 ± 0.11	2.70 ± 0.92			0.245	0.987	0.73
15°C	6.02 ± 0.09		1.71 ± 0.08	1.61 ± 0.12	3.01 ± 0.30			0.145	0.995	0.32
20°C	5.87 ± 0.25		1.43 ± 0.20	2.38 ± 0.40	2.22 ± 0.54			0.357	0.976	1.52
RBF NN[f]	**Radial Basic Function Neural Network (RBF NN)**									
5°C								0.218	0.992	1.59
10°C								0.216	0.993	0.57
15°C								0.155	0.996	0.36
20°C								0.265	0.989	0.84

Failure (?) of models to describe the data at 50 C (but NN)

Contribution of individual strains in the cocktail experiments at the end of storage of katiki cheese stored at different temperatures

Temperature °C	% contribution of *Listeria monocytogenes* strains				
	TS124	TS125	TS128	TS131	TS133
5° C	0	0	0	100	0
10° C	0	95	0	0	5
15° C	18	68	0	14	0
20° C	0	78	5	3	14

Kagkli et al (2009) AEM

Provisional text

JUDGMENT OF THE COURT (Eighth Chamber)

30 June 2022 (*)

(Reference for a preliminary ruling – Food law– Regulation (EC) No 2073/2005 – Microbiological criteria for foodstuffs – Article 3(1) – Obligations of food business operators – Annex I – Point 1.2 of Chapter 1 – Limit values for the presence of Listeria monocytogenes in fish products before and after being placed on the market – Regulation (EC) No 178/2002 – Article 14(8) – Official controls of the product at the stage at which it is placed on the market – Scope)

In Case C-51/21,

REQUEST for a preliminary ruling under Article 267 TFEU from the Tallinna Halduskohus (Administrative Court, Tallinn, Estonia), made by decision of 28 January 2021, received at the Court on 28 January 2021, in the proceedings

On those grounds, the Court (Eighth Chamber) hereby rules:

The combined provisions of Article 3(1) and point 1.2 of Chapter 1 of Annex I to Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs, as amended by Commission Regulation (EU) 2019/229 of 7 February 2019, must be interpreted as meaning that, where the manufacturer is unable to demonstrate, to the satisfaction of the competent authority, that, throughout their shelf-life, foodstuffs will not exceed the limit of 100 colony-forming units/grams (g), as regards the presence of *Listeria monocytogenes*, the limit requiring the absence of detection of *Listeria monocytogenes* in 25 g of the food product concerned laid down in that point 1.2 of that Annex I, *does not apply to foodstuffs which have been placed on the market throughout their shelf-life*.

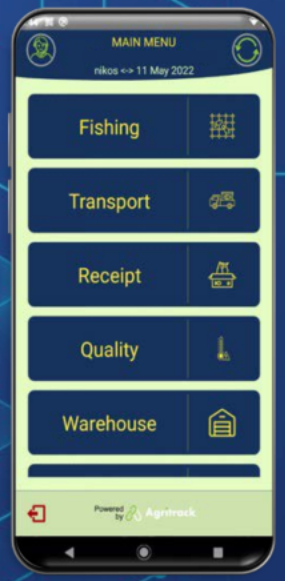
[Signatures]

Agritrack

FISH-TRACK
ELEVATING AQUACULTURES

TRACEABILITY AUTOMATION
RECORD & SECURE

01



IOT & LEDGER

QUANTIFIABLE
QUALITY MONITORING

02

Predictive Microbiology
Artificial Intelligence & NIR

FOOD VALUE CHAIN INTELLIGENCE
INFORM CONSUMERS

03

QR Code

QUALITY FROM FARM TO FORK

Digitize, track & improve operations

Assess fish expiration date, safety and freshness

Enhance marketing
Show provenance and quality

Logout About

Lot: **029099** | Fish Date: **02/06/2023** | Timezone: **UTC+03:00**

Species: **BREAM** | Batch #: **1705231** | # Bins: **10**

Min Temp: **1.69°C** | Max Temp: **10.97°C** | Span: **168 hours**

Estimated Shelf Life:

Action	Date	Location
Hatched	08/12/2020 03:34	FARM 1
Fished	02/06/2023 06:39	FARM 1
Transport	02/06/2023 07:45	FARM 1
Plant	02/06/2023 10:49	PLANT 1
QC	02/06/2023 11:12	PLANT 1
Packaged	02/06/2023 11:18	PLANT 1
Dispatched	02/06/2023 16:21	PLANT 1
Received	02/06/2023 20:25	DISTRIBUTION 1
Shipped	03/06/2023 13:22	DISTRIBUTION 1
Delivered	09/06/2023 09:55	RETAIL 1
Scanned	09/06/2023 22:09	RETAIL 1

Temps/Lot

Indicative shelf life graph

In total there have been collected about ca 25000 measurements from 10000 samples [Vibrational Spectroscopy & Machine Learning analysis]

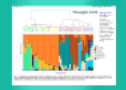
Data Acquisition [food spoilage, drug residues, food pathogens]

Having in mind paragraph (24) of EU 2073/2005

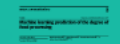
(24) ..... food business operators should have the possibility to use analytical methods other than the reference methods, in particular more rapid methods, as long as the use of these alternative methods provides equivalent results. Moreover, a sampling plan needs to be defined for each criterion in order to ensure harmonised implementation.

It is nevertheless necessary to allow the use of other sampling and testing schemes, including the use of alternative indicator organisms, on condition that these schemes provide equivalent guarantees of food safety.

Next Generation Sequencing



Coming Trends



Coming Trends

Having in mind paragraph (24) of EU 2073/2005

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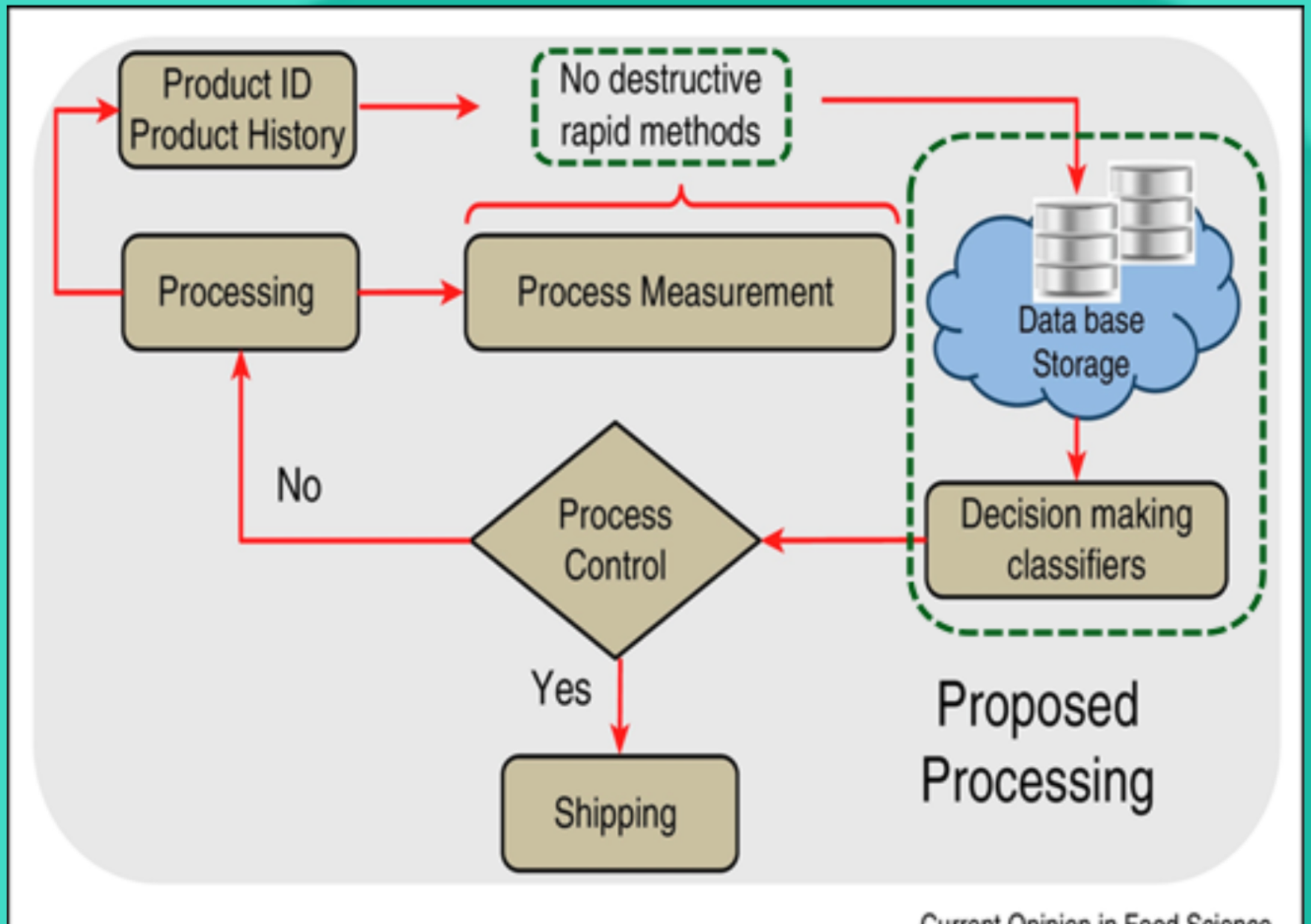
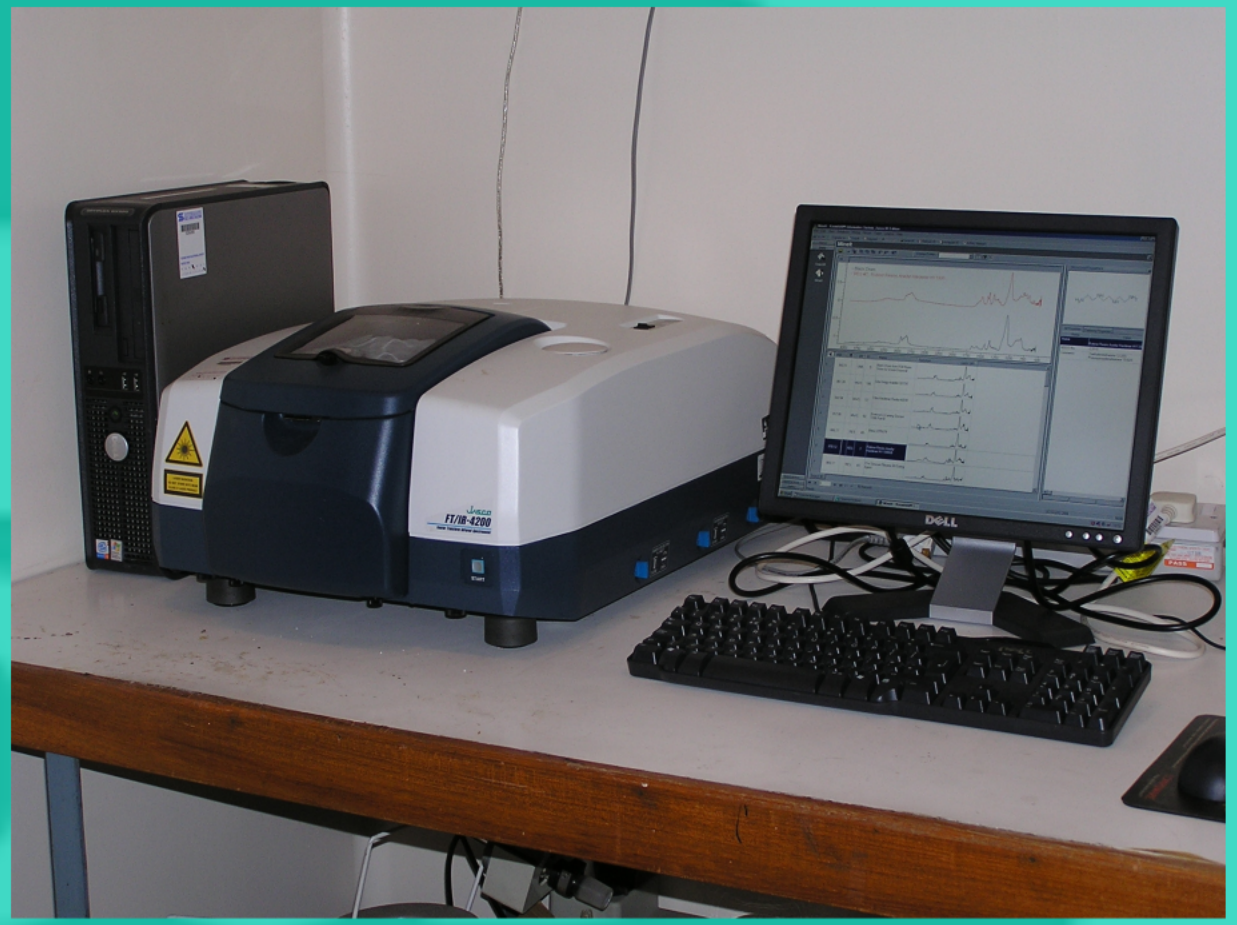
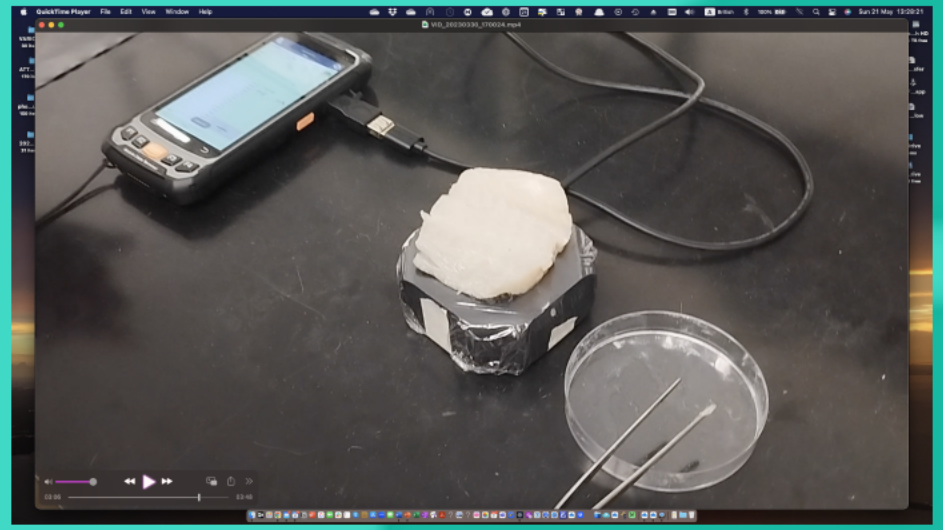

Product ID
Product History
No destructive
rapid methods
Processing
Process Measurement
Data base
Storage
No
Process
Control
Decision making
classifiers
Yes
Shipping
Proposed
Processing


FT/IR-4200
DELL

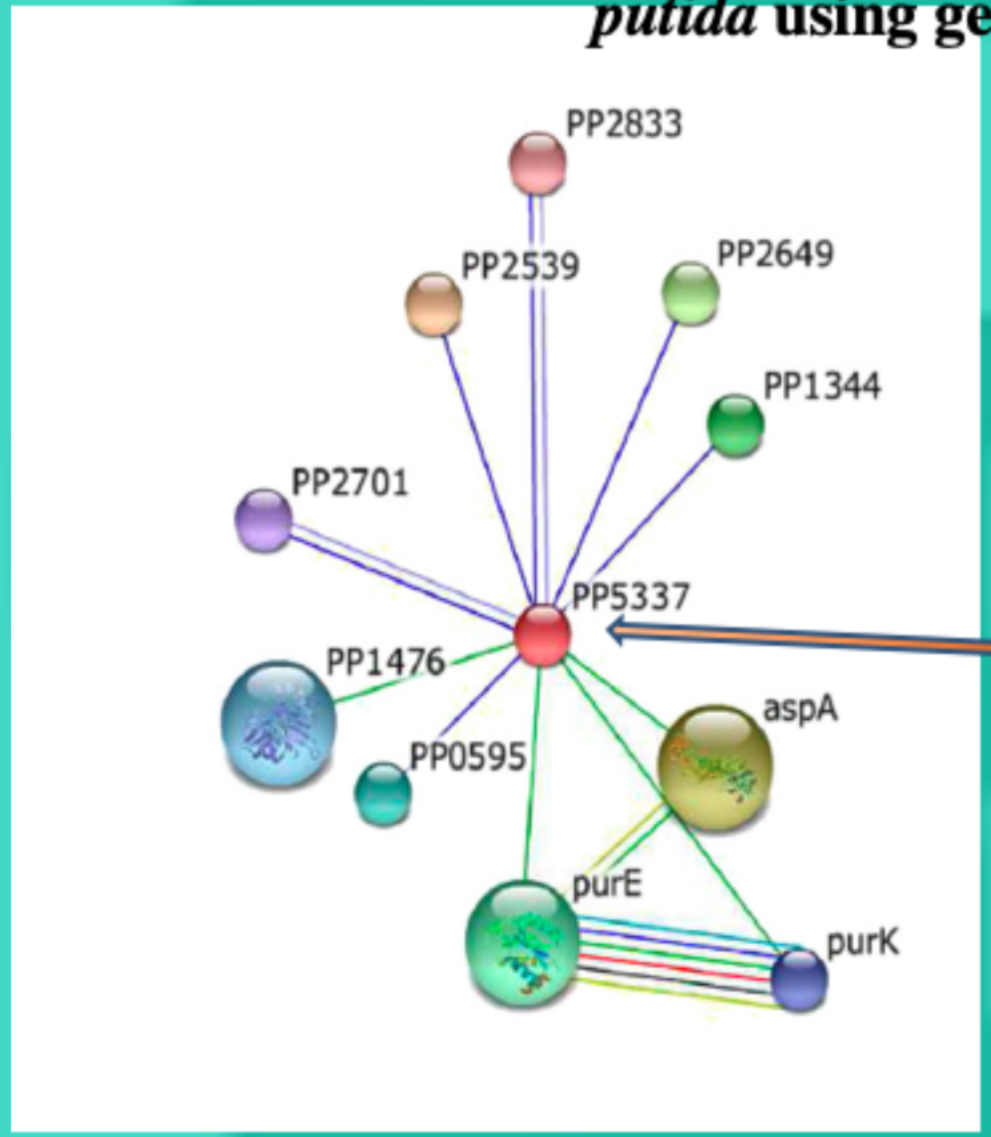


In total there have been collected about ca 25000 measurements from 12000 samples [Vibrational Spectroscopy & Machine Learning analysis]

Data Acquisition [food spoilage, drug residues, food pathogens]

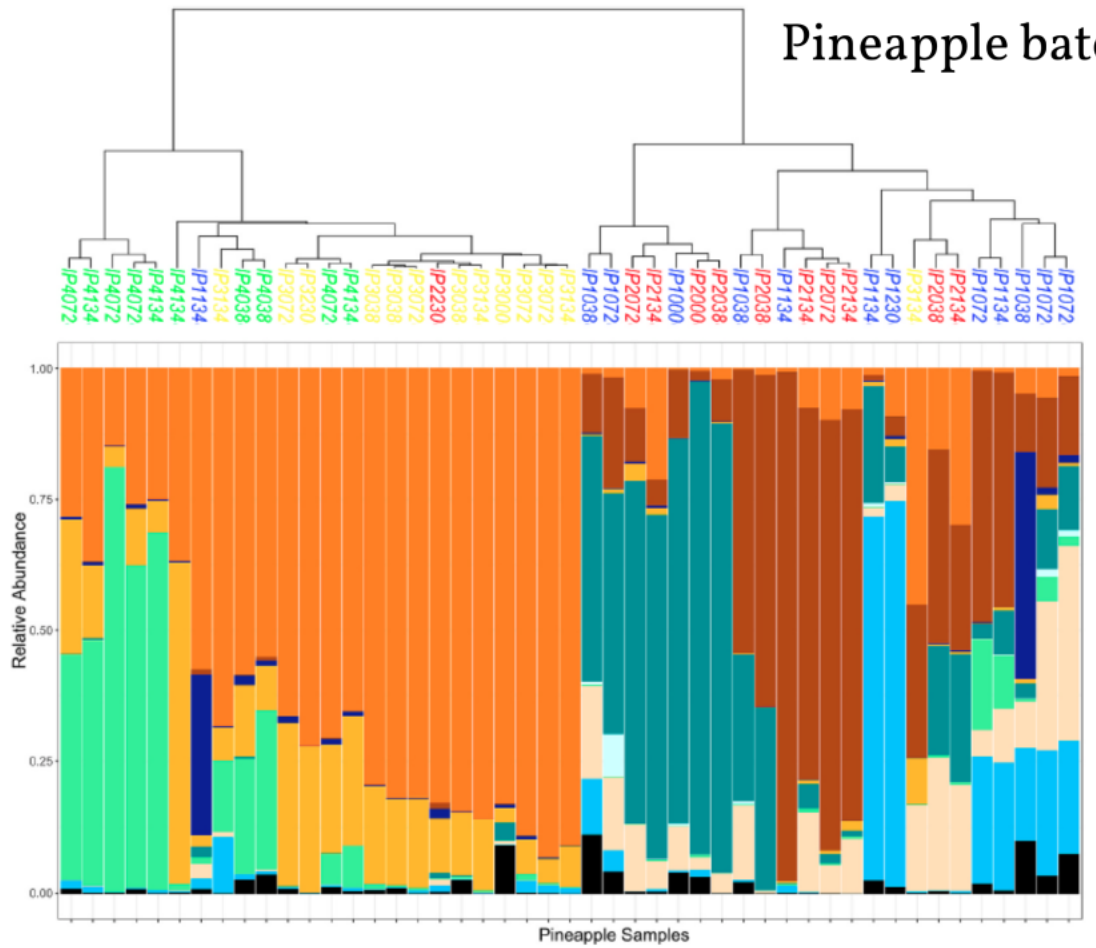
Next Generation Sequencing

Identification of meat spoilage gene biomarkers in *Pseudomonas putida* using gene profiling



Gene "PP5337" is found to be directly linked with "aspA" (aspartate ammonia-lyase) and "purE (phosphoribosylaminoimidazole regulator), indicating that it can also be associated with the malodours production i.e aerobic spoilage

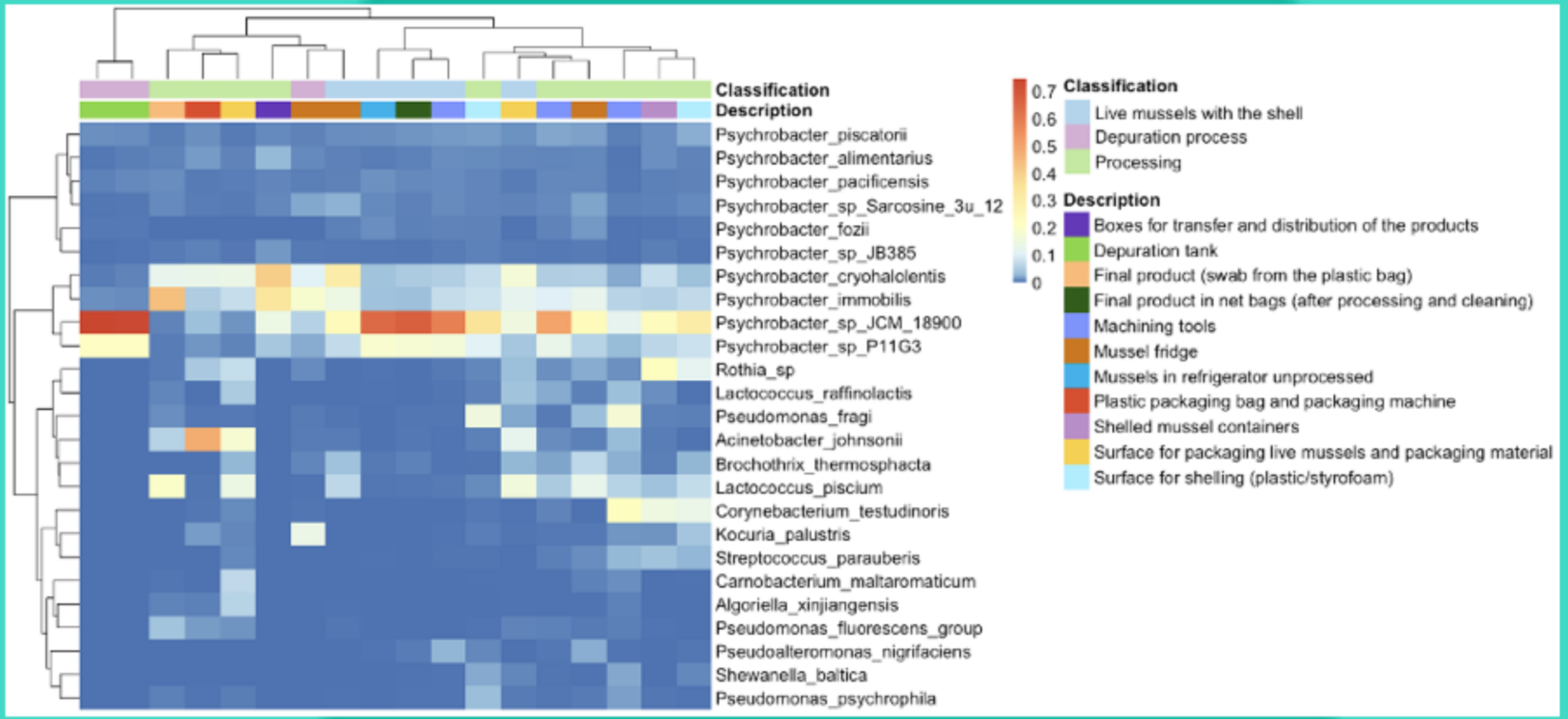
Mohareb et al. 2015 Food Control 57, 152-160



Metagenomics/ Metagenetics; Provides an excellent framework for studying the FOOD MICROBIAL ECOSYSTEM e.g. interaction between different species or interaction between food matrix and environmental conditions during storag

Fig. 5. Composition plot showing the relative abundances of the nine main Ascomycota species found in Pineapples samples. On the top: hierarchical clustering of batches samples according to Bray-Curtis distance and ward algorithm (blue for P1, red for P2, yellow for P3 and green for P4 as shown in Fig. 4). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

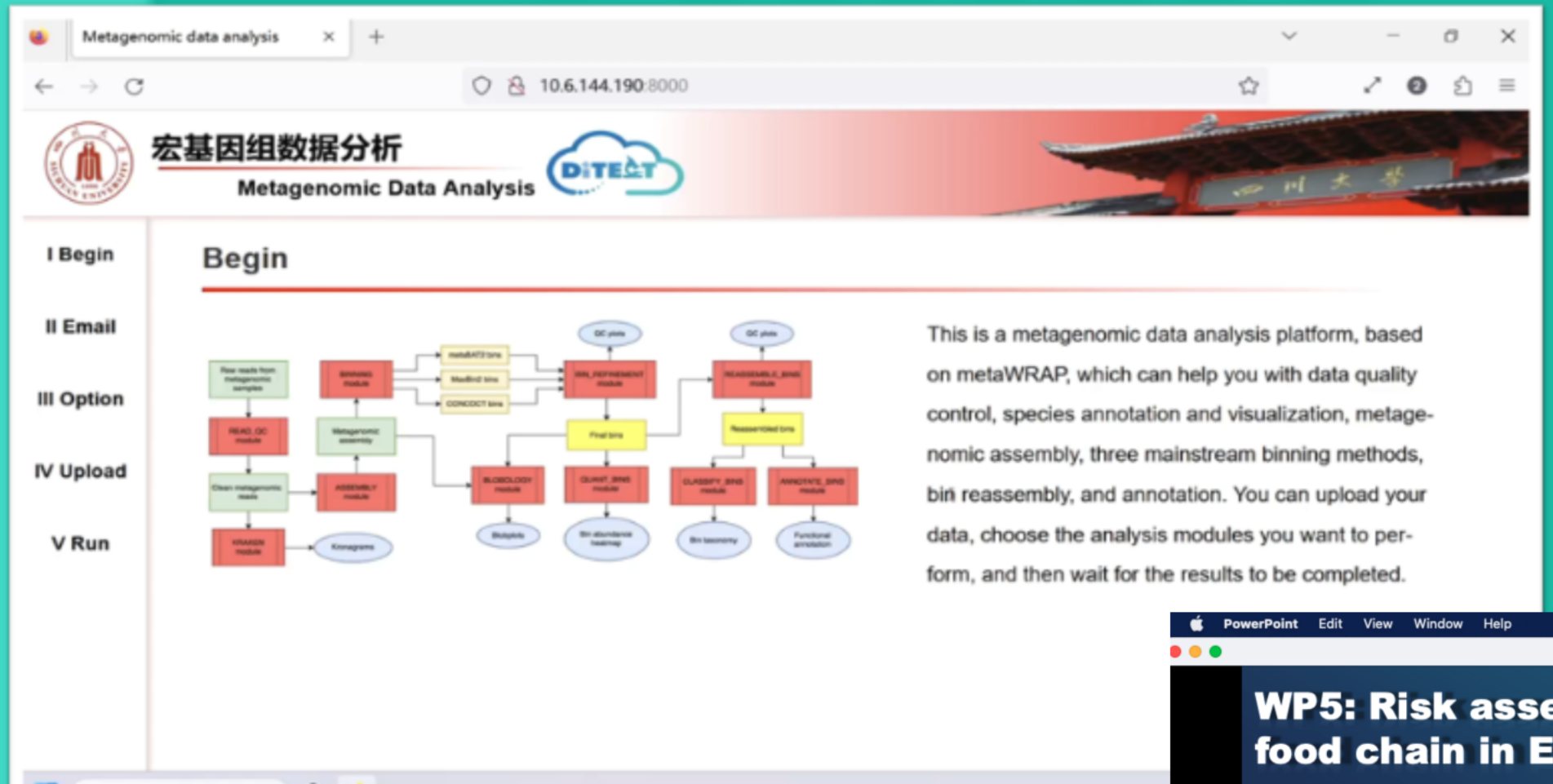
Mussels processing plant – Batch 2 or 5 - UNINA



WP5: Risk assessment of biological, chemicals hazards across food chain in EU and China (SCU)

四川大學 SICHUAN UNIVERSITY

Macrogenomic Analysis Platform: Flow path and Demo



tation. You can upload your
modules you want to per-
results to be completed.

PowerPoint Edit View Window Help

PowerPoint Slide Show – [ppt-0529的副本]

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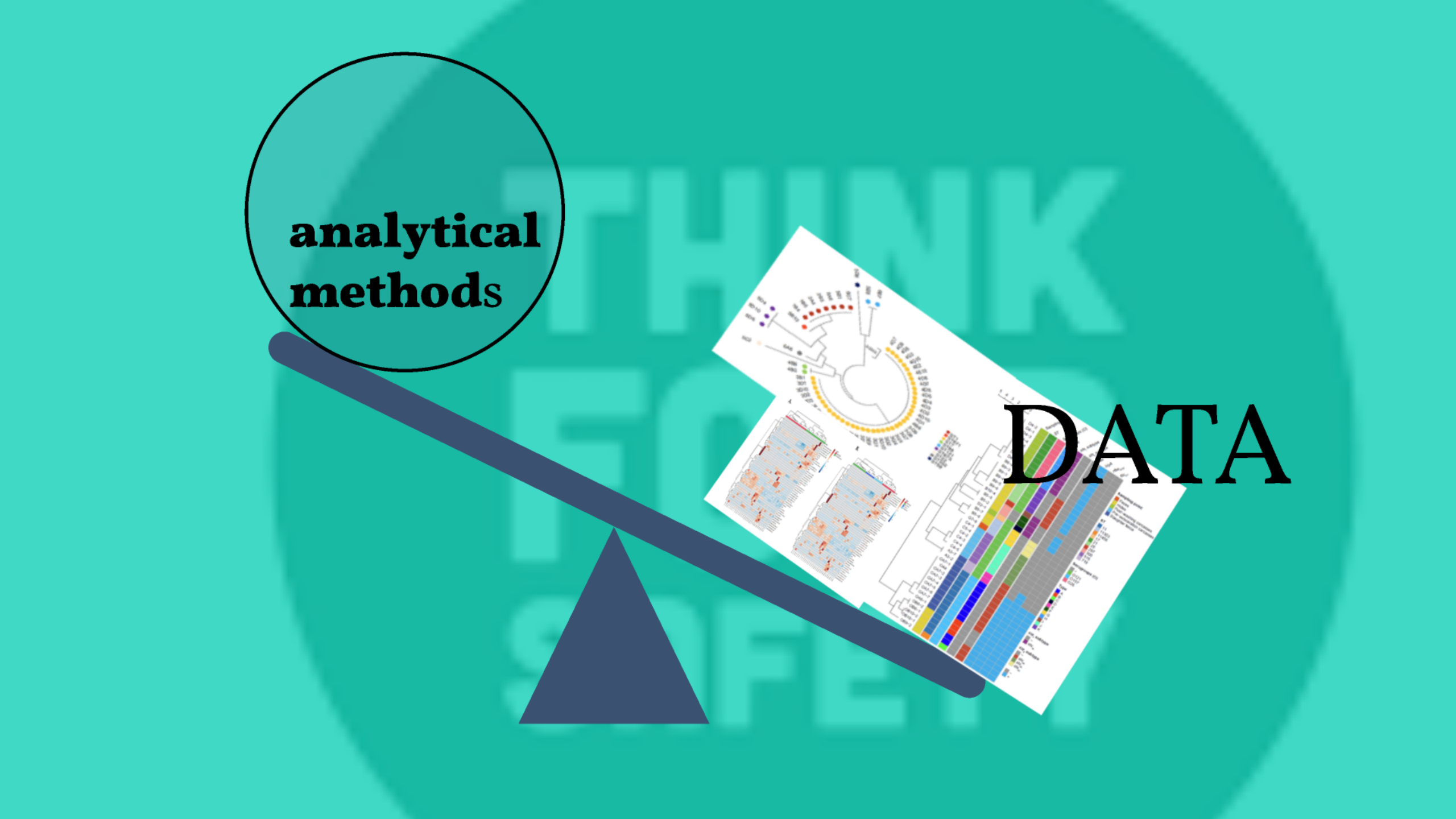

analytical
methods
DATA

nature communications

Article

https://doi.org/10.1038/s41467-023-37457-1

Machine learning prediction of the degree of food processing

Received: 7 May 2022

Accepted: 16 March 2023

Giulia Menichetti[1,2], Babak Ravandi[2], Dariush Mozaffarian[3,4] & Albert-László Barabási[2,5,6]

NOVA is a classification system widely used in epidemiological studies, assessing the extent and purpose of food processing.

It categorizes individual foods into four broad categories:

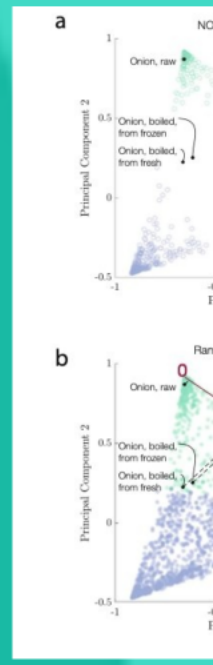
NOVA 1: unprocessed or minimally processed , like fresh, dry, or frozen fruits or vegetables, grains, legumes, meat, fish, and milk; processed culinary ingredients

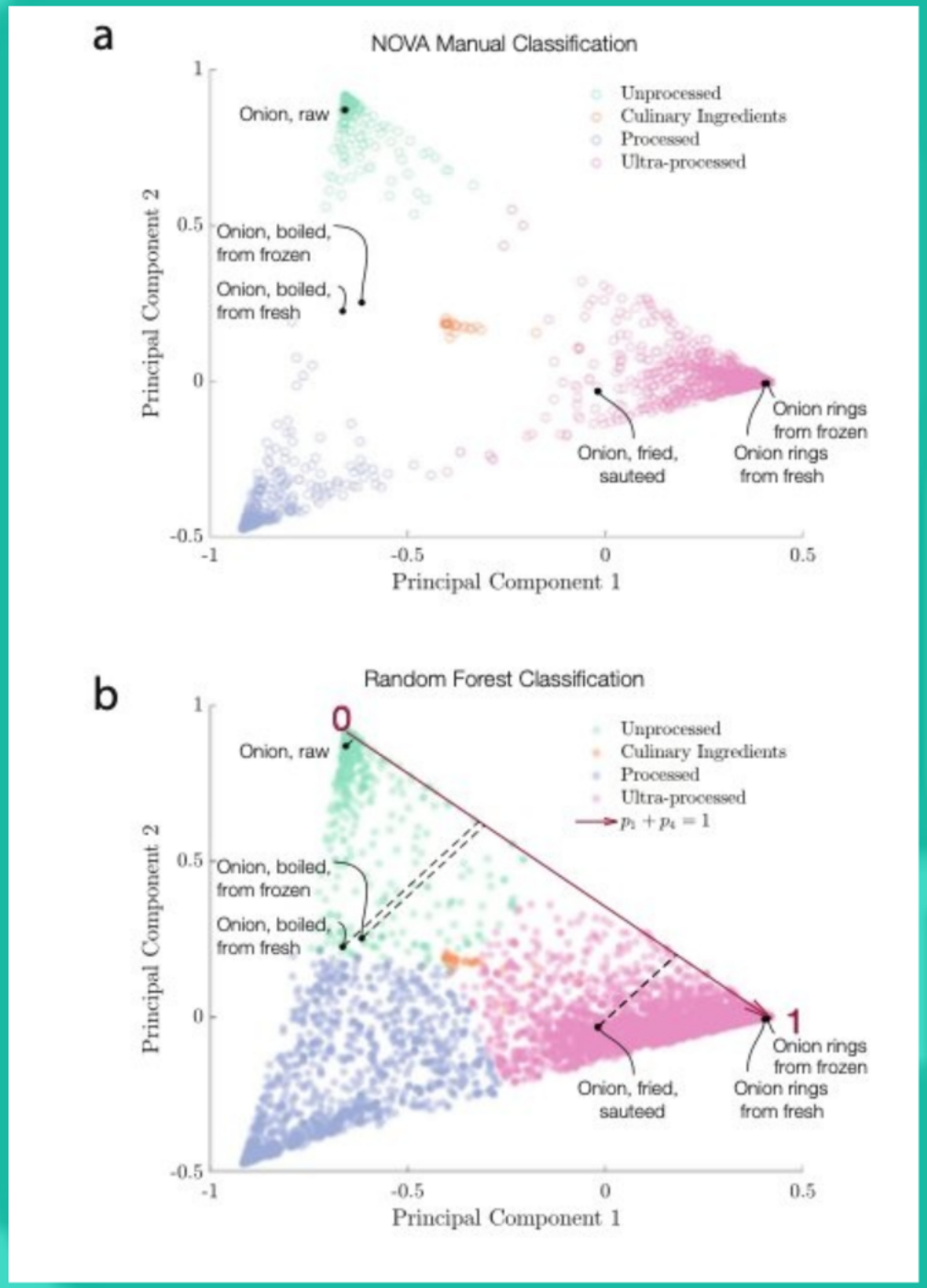
NOVA 2:, like table sugars, oils, fats, and salt;

NOVA 3:, Processed foods like canned food, simple bread, and cheese; and

NOVA 4: Ultra processed products industrial formulations typically of five or more ingredients including substances not commonly used in culinary preparations, such as additives whose purpose is to imitate sensory qualities of fresh food.

Epidemiological studies have documented significant associations between greater consumption of NOVA 4 and disease onset, including links to obesity, CHD, diabetes mellitus, cancer, and depression.




a
NOVA Manual Classification
Unprocessed
Culinary Ingredients
Processed
Ultra-processed
Onion, raw
Onion, boiled, from frozen
Onion, boiled, from fresh
Onion, fried, sauteed
Onion rings from frozen
Onion rings from fresh
Principal Component 2
Principal Component 1
b
Random Forest Classification
0
1
$p_1 + p_4 = 1$
Unprocessed
Culinary Ingredients
Processed
Ultra-processed
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Onion, boiled, from frozen
Onion, boiled, from fresh
Onion, fried, sauteed
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Principal Component 2
Principal Component 1

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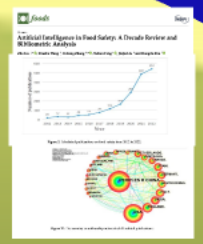
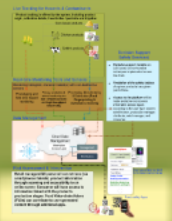
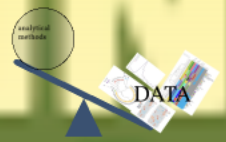




Cloud platforms and data repositories should be coupled with appropriate web applications in order to assist producers with their expenditure and planning decisions.

INTERNET of FOODS



An explosion of data – on chain
The gradual move from paper-based one-up, one-down records to extensive electronic records
Automatic data capture, via barcodes, RFID, IoT, integrated into ERP systems (e.g. Returnable Transport Items with RFID or even IoT devices)
On the farm: weather stations, sensors in the soil, on livestock, in machinery, from drones and Earth Observation.
In the food processors: ERP systems capturing GS1 EPCIS events, processing, packaging, transforming.
In the logistics steps: GPS tracking, sensors monitoring (e.g. temperature, humidity)

Data Science; Data mining, Data analysis, Machine Learning

The massive amount of data generated by various analytical and high throughput platforms is a challenging issue for food safety.

AN EXPLOSION OF DATA - OFF CHAIN
Two areas:
a. **Food safety data collection**
Traditional methods i.e. sample based microbiological laboratory analyses ("finished product testing")
More recently non-destructive methods – so called "process analytical technology" (Nychas et al. 2008) (e.g. FTIR spectral [sets of mathematical modelling, growing use of machine learning and deep learning (Ryckaert et al. 2021)
(Here we are not concerned with limitations/ capabilities of these approaches only to say they generate a lot data – but where is it? Who has access?

a. **Food certifications:**
or quality Schemes of food (GlobalGAP, organic, Fairtrade, and many other certification systems)
In all these cases data resides with different organizations and institutions but is not available to the community

Live Tracking for Hazards & Contaminants

Product tracking is offered by the system, including product origin, cultivation details, Insecticides / pesticide and Irrigation

Corn-based products

Chicken products

Cattle's products

Real-time Monitoring Tools and Sensors

Monitoring biological, chemical Hazard(s) with non-destructive sensors

Phenotyping and field-level hazard monitoring

Primary production & animal monitoring via **non- invasive sensors** and **high throughput sequencing**

Processing, Manufacturing & Distribution (**Food Fingerprinting & mathematical modeling**

Data Management

Cloud Data Management

Information Access Layer

Management

Distribution

Risk Assessment & Intervention

Retail managers/QC personell can retrieve (*via* smartphones /tablets) product information through scanning and accessibility to an online server. Consumer will have access to information linked with the product's production stages. Food Value-chain Actors (FVAs) can contribute to user-generated content through additional apps.

Decision Support Safety Services)

- ***Decision-support models*** are built based on non-invasive techniques implemented across the chain
- ***Prediction of the safety indices*** of a given product at any given point of time.
- ***Access to the platform*** will be made available over several information access layers according to the user type: system administrator, production manager, distributer, retail manager, and consumer.

smartphone

Corn & food (meat) products

Product Origin

Reviews

Nutrition Value

Food Miles

Safety Profile

Tracking information

Predictive Hazard e.g. (mycotoxin, pathogen)

User generated content & Communication Apps

Food safety Apps

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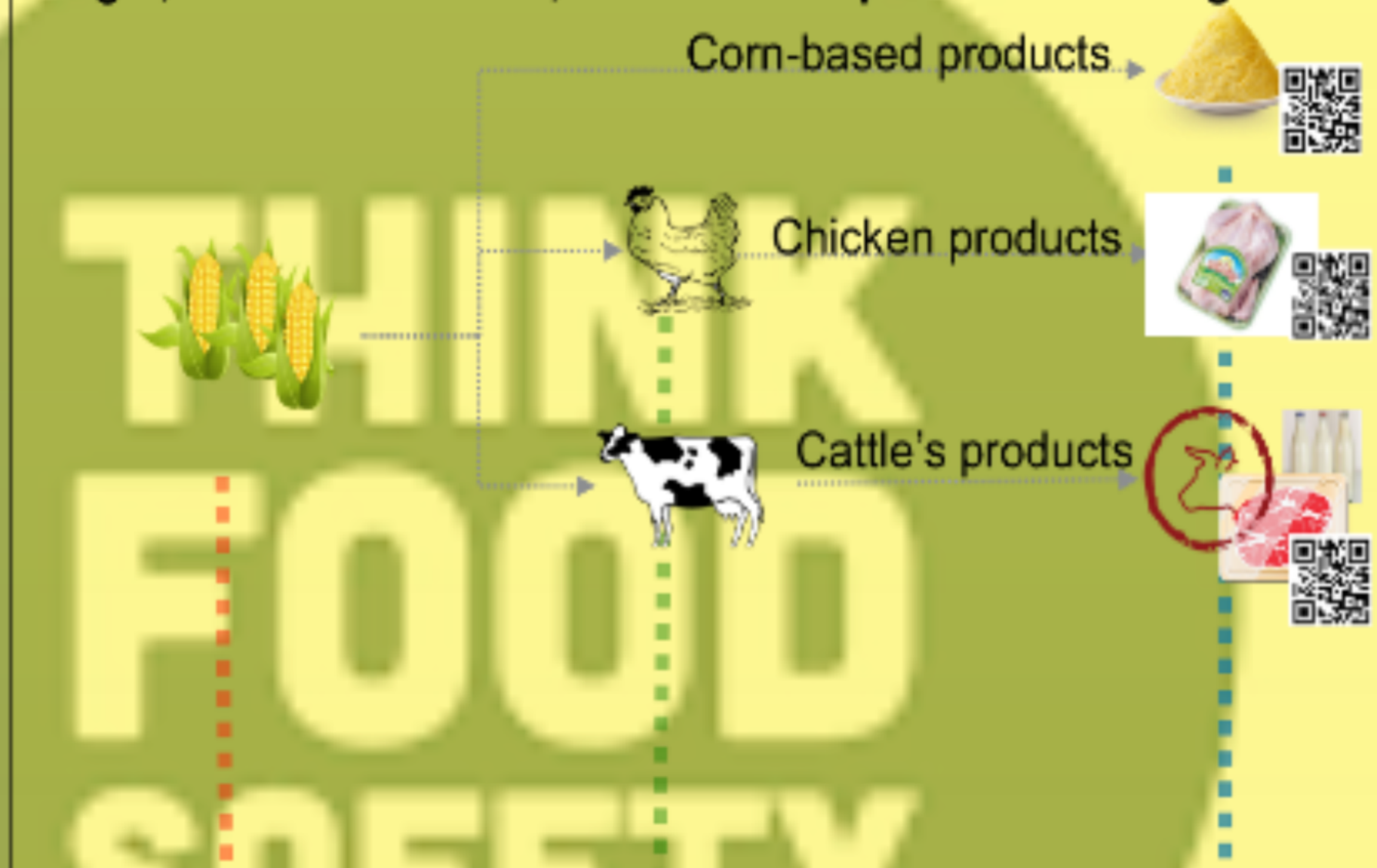

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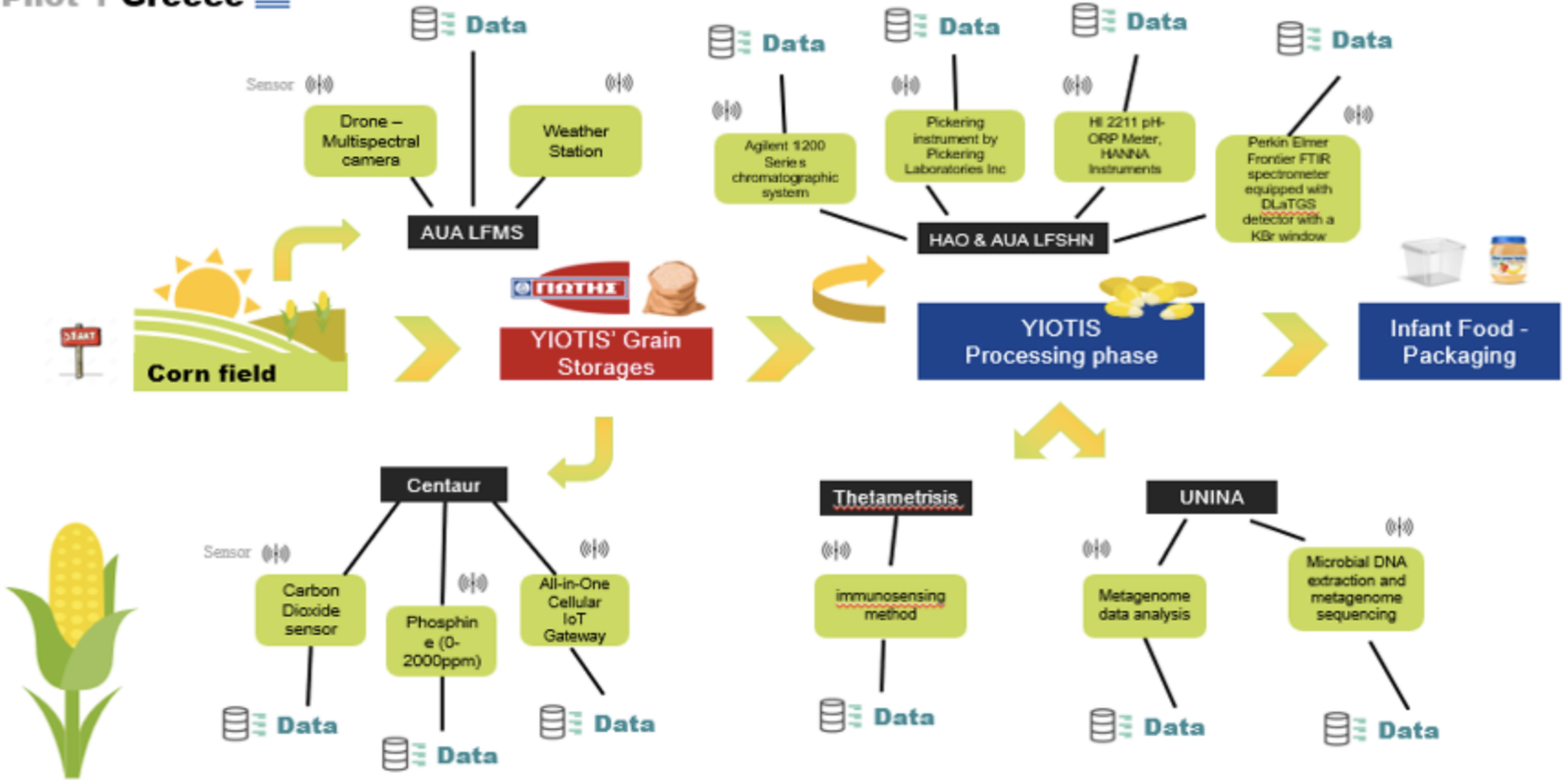
Pilot 1 Greece



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Lots of mathematical modelling, growing use of machine learning and deep learning (Nychas et al. 2021)

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analytical methods

DATA

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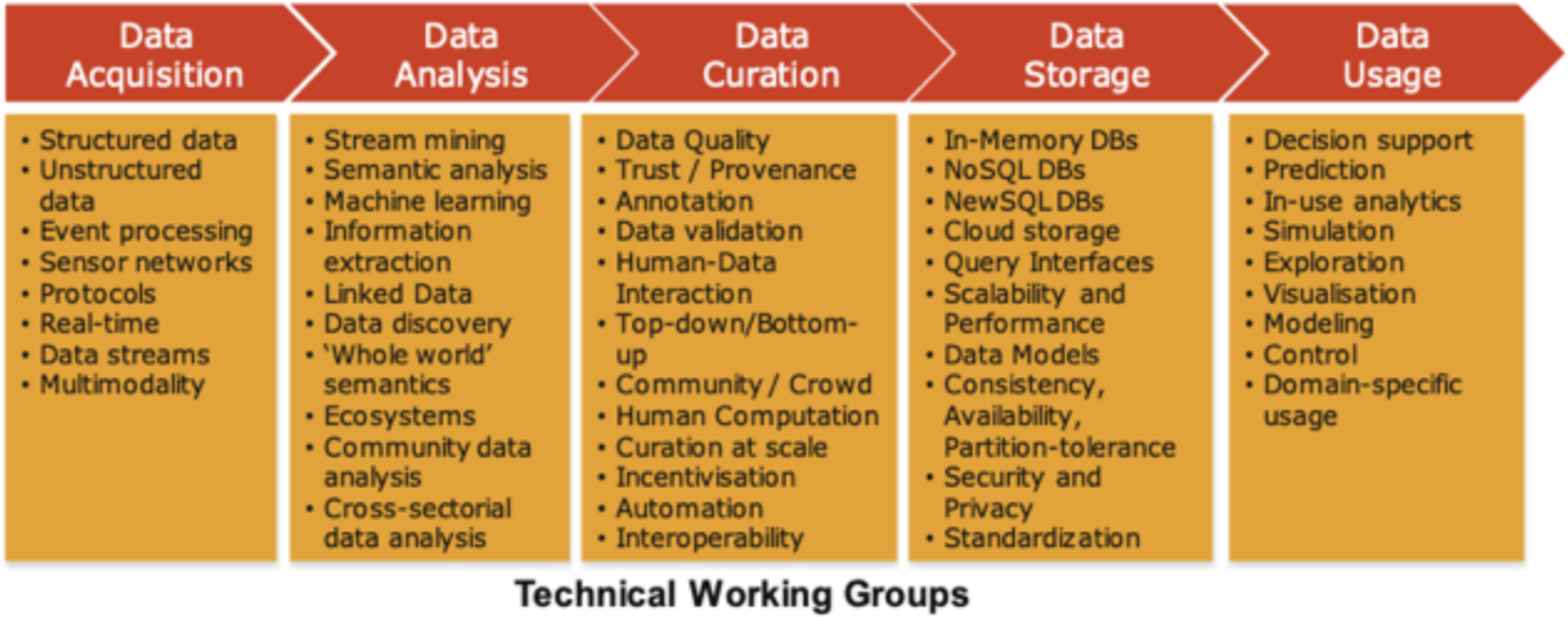

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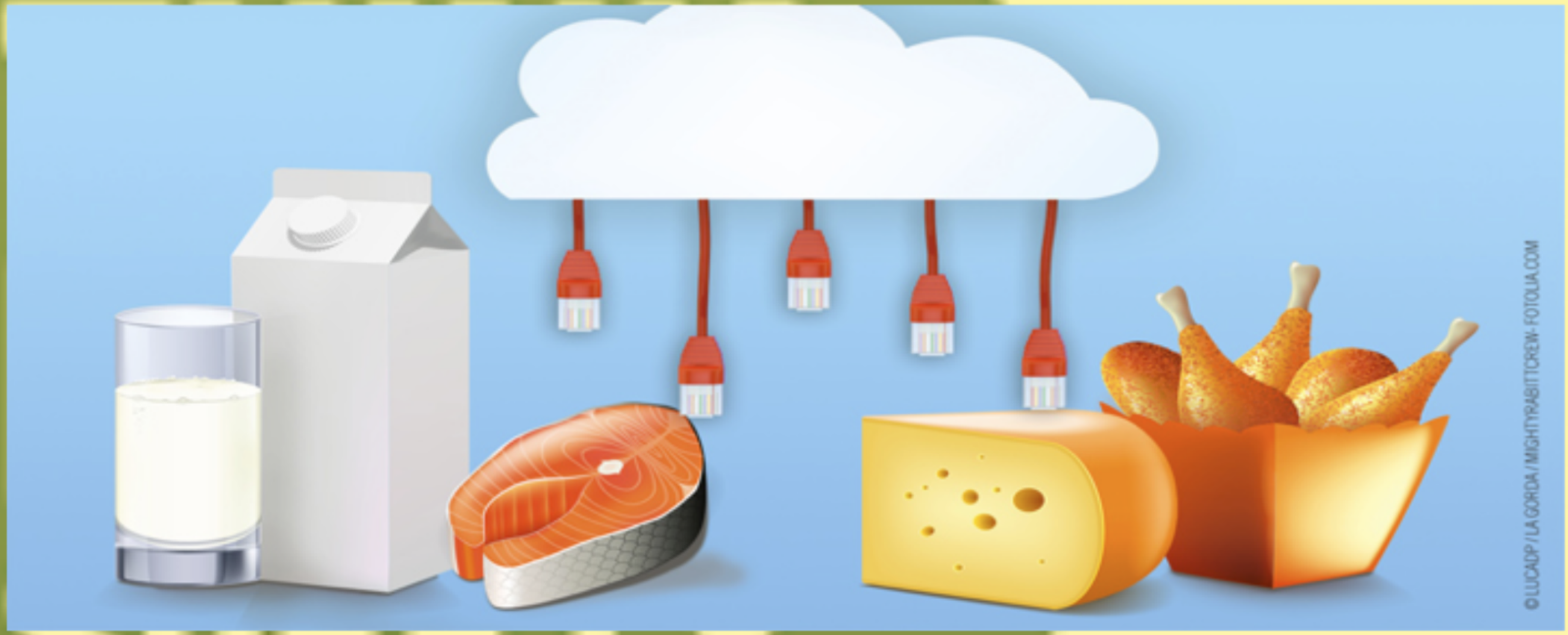

foods

MDPI

Review

Artificial Intelligence in Food Safety: A Decade Review and Bibliometric Analysis

Zhe Liu [1,*], Shuzhe Wang [1], Yudong Zhang [2,*], Yichen Feng [1], Jiajia Liu [1] and Hengde Zhu [2]

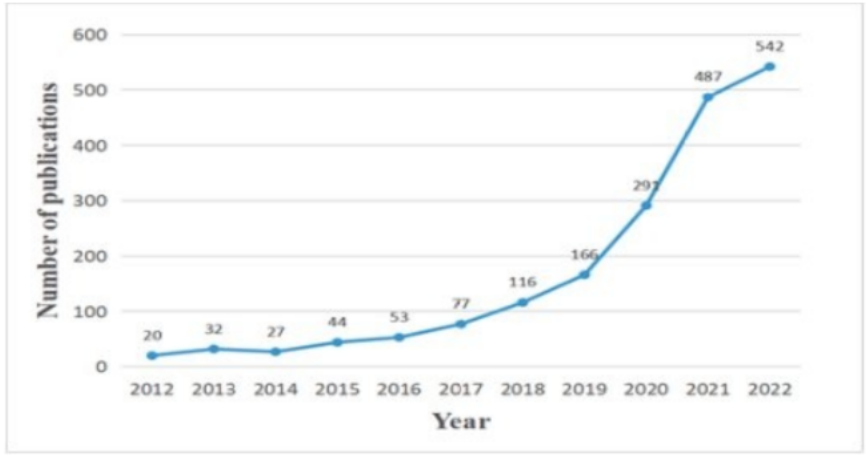

Figure 2. AI-related publications on food safety from 2012 to 2022.

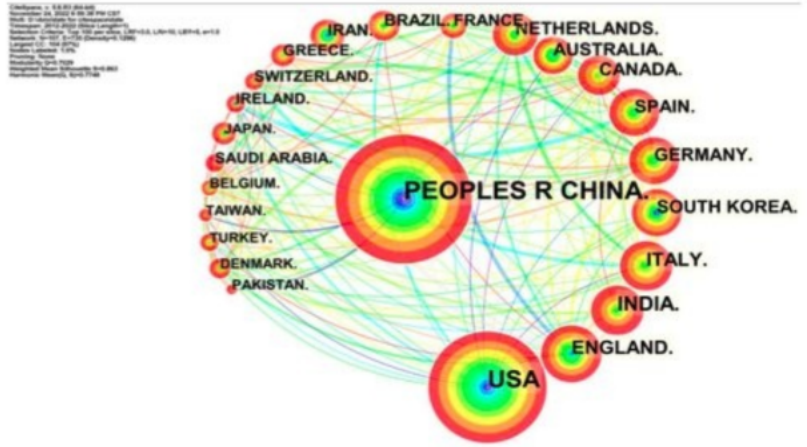

Figure 11. The country co-authorship network of AI-related publications.

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Food Safety and Quality under the Auspices of Data Science
IAFP : Webinar 24/10/2023

George-John NYCHAS
Agricultural University of Athens - Greece