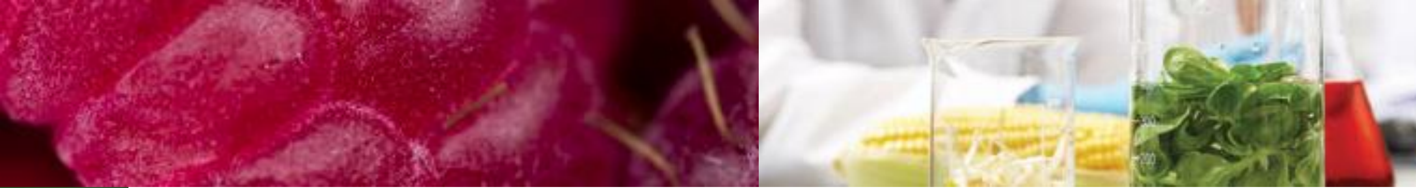

Data Science in the Food Industry

Moderator: Panagiotis Skandamis, *Researcher,*
Agricultural University of Athens, Greece

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International Association for Food Protection WEBINAR

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- Questions should be submitted to the presenters during the presentation via the Questions section at the right of the screen. Questions will be answered at the end of the presentations.
- This webinar is being recorded and will be available for access by IAFP members at www.foodprotection.org within one week.

Today’s Moderator

Panagiotis Skandamis, Moderator
Researcher, Agricultural University of Athens, Greece

Dr. Panagiotis N. Skandamis is Professor of Food Microbiology and Food Quality Control and Food Hygiene in the Agricultural University of Athens and member of the BIOHAZ panel of European Food Safety Authority (EFSA). He has worked as a post-doctoral fellow in the Department of Animal Science of Colorado State University in USA. In 2004, he joined the Department of Food Science & Technology of AUA. Dr. Skandamis has (co-) authored 187 original research papers in journals of SCI, 30 book chapters, another two, currently under preparation, edited 1 book and has a total number of 7042 citations (h-index 37).

His research is funded by 5th-7th EU Framework Programs, HORIZON 2020, competitive Grants from Greek Research and Technology Funding Agency, as well as direct contracts with the Greek Food Industry in the following areas: (i) active antimicrobial and intelligent packaging of foods; (ii) food spoilage and safety; (iii) biofilm formation and removal by chemical and natural disinfectants, (iv) predictive microbiology of foods and quantitative microbial risk assessment, (v) application of antimicrobial interventions; (vi) detection, isolation and subtyping of foodborne pathogens from foods and food processing environments.

He has been Associate Editor in Food Research International (2012-2017). Currently he is serving as scientific co-editor in Journal of Food Protection and member of the Editorial Board in Applied and Environmental Microbiology, International Journal of Food Microbiology and Frontiers in Microbiology.

Dr. Skandamis is member of the scientific committee of International Conference in Predictive Microbiology in Foods (ICPMF) since 2008, member of the organizing committee of European symposium of International Association of Food Protection (IAFP) since 2015, and current co-President of the FoodMicro 2020. He is also Chair of the Professional Development Group of “Microbial Modelling and Risk Assessment” of IAFP.

Predictive Modeling software development: Dr. Skandamis is the developer of GroPIN (www.aua.gr/psomas), a Predictive Modelling Software tool, which constitutes a database of >400 kinetic and probabilistic models for pathogens and spoilage organisms in response to a variety of intrinsic and extrinsic foods parameters (e.g., T, pH, aw, preservatives, atmosphere, etc.).

Today’s Presenters

George Nychas
Professor, Agricultural University of Athens, Greece

George Nychas is Professor in Food Microbiology in the Dept of Food Science & Human Nutrition of Agricultural University of Athens (Greece). The last 25 years coordinated 6 European Projects and participated in more than 35 EU projects (budget >15 M €).

Through these projects, the team of Prof. G-J., Nychas has acquired extensive experience on; (a) on modelling the behaviour of microbial populations throughout the food chain to assist reliable estimation of microbial food safety risk (b) Implementation of Process analytical technology (PAT) in Food Industry introducing sensors (non destructive non- invasive) (c) the assessment of food safety and spoilage through microbiological analysis in tandem with metabolomics and data mining.

So far he has published 284papers (Scopus) with ca. 14700 citations and h=71 and he is (i) Chairman of food safety group of European Technological platform food for life (ii) member of the pool of scientific advisors on risk assessment for DG SANCO, while he served as co-chair (2008-2010) in the Professional Development Group of “Microbial Modeling and Risk Analysis" of International Association for Food Protection, member of the Biohazard panel and the Advisory Forum of EFSA, external expertise to the European Parliament, President of the Greek Food Authority.

Recently (Nov 2018) he was listed among the top 1% of highly cited researchers in the field of Agriculture Science (Web of Knowledge – Clarivate)

International Association for Food Protection
WEBINAR

Data Science in the Food Industry

George-John NYCHAS

Laboratory of Microbiology and Biotechnology of Foods,
Department of Food Science and Human Nutrition
Agricultural University of Athens, Athens, Greece

WEBINAR’s STRUCTURE

- Food Safety vs. Food Quality
- Monitoring Food Safety, Quality; Tools
- Current and Next Generation Strategies
- Challenges of Data Sciences on food safety and beyond

WEBINAR's STRUCTURE

- Food Safety vs. Food Quality

QUALITY vs SAFETY

Food safety is dealing with all those hazards, whether chronic or acute, that may make food injurious to the health of consumers, and is not negotiable.

Quality includes all other attributes that influence a product's value e.g. spoilage, flavour, texture, contamination and adulteration.

The temptation to increase stocks to meet consumer demands have never been higher than during the initial COVID-19 lockdowns, which saw consumers mass stockpiling goods.

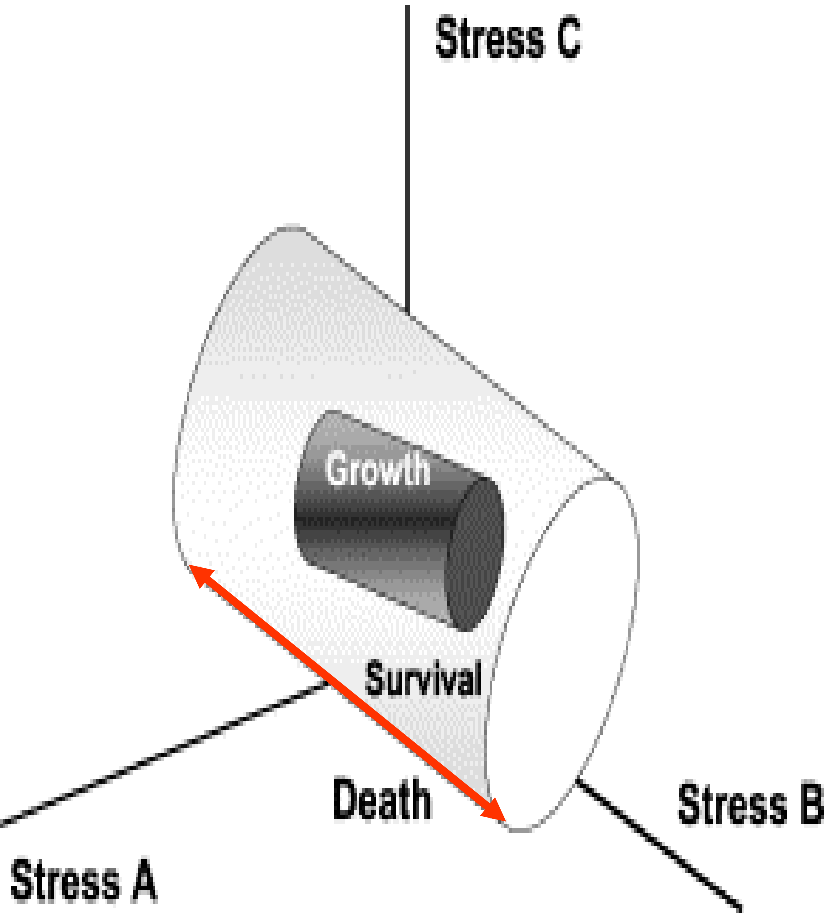
QUALITY vs SAFETY

According to FAO /WHO "access to quality and safe food is a fundamental individual right". Guaranteeing this right is an important priority among the Governments

SHARED RESPONSIBILITY

- USA; among many *different points in the global supply chain* for both human and animal food - Food Safety Modernization Act (FSMA)
- CHINA; *Food producers and Traders*
- EU; *Food Business Operators* that have the primary responsibility, *Authorities* that monitor this responsibility, and *Consumers* who must also recognize that they are responsible for the proper storage, handling, and preparation of food.

Food Safety vs Food Quality: A relationship of life, death, survival of m/o in the food environment (Food Microbial Ecology- R.G. Board 1982)



Booth (2002) Int. J. Food Micro 15,19-30

The Comfort Zone

In Food Microbiology the comfort zone is under investigation;

"Comfort Zone" is the zone in which organisms are either growing or surviving, and which represents to a significant degree the intrinsic resilience of the organism and its ability to adapt to and resist the consequences of DYNAMIC changes in SPACE and in TIME in the (FOOD) environment

QUALITY vs SAFETY

How safe is my food ???

How to tell if expired food is safe to eat?

Is food still ok to eat even after the expiration date?

WEBINAR’s STRUCTURE

- **Monitoring Food Safety, Quality; Tools**
    - Sensory analyses
    - Conventional & Molecular Microbiology
    - Chemical analyses
    - Mathematical modelling

Sensory Evaluation

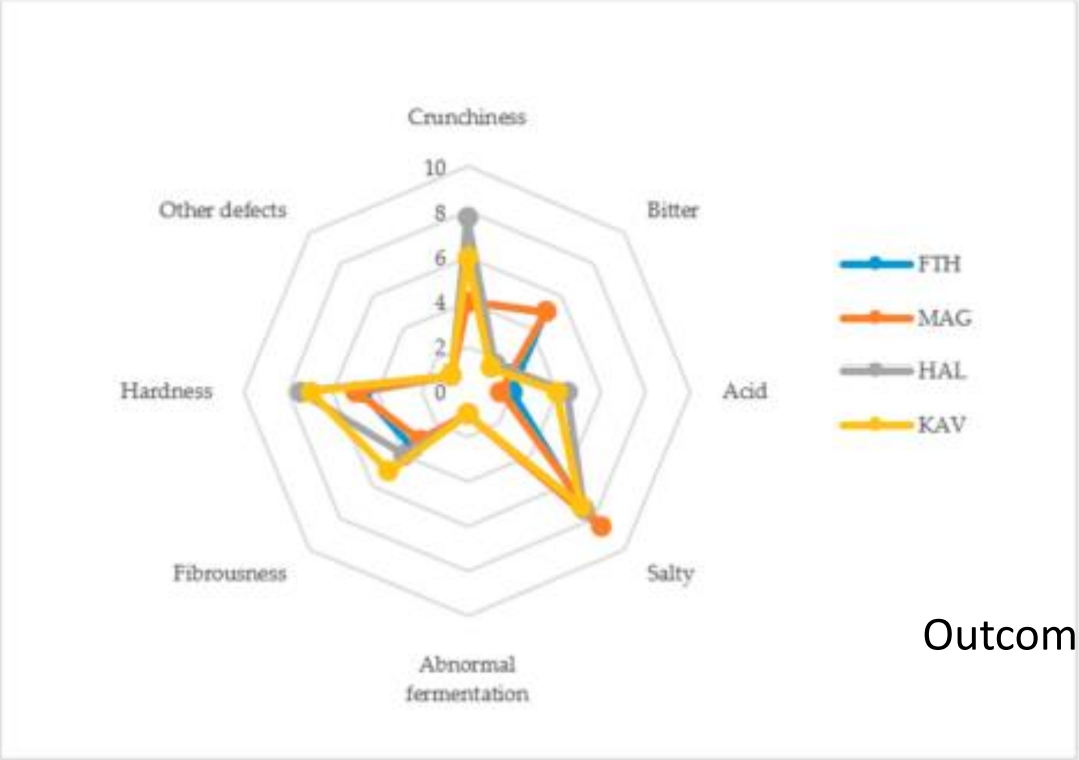


Figure 2. Spider graph showing the sensory profiles (original scores) for the diverse fermented table olives samples. FTH (origin, Fthiotida; cultivar, Konservolia), MAG (Magnesia; Konservolia), HAL (Halkidiki; Halkidiki), KAV (Kavala; Halkidiki).

Spider graph depicting quality characteristics

Outcome's availability; less than 1 H

Microbiological Molecular approaches

Outcome's availability; 18 to 48H

Chemical approaches

The Chemical indicators/ microbial metabolites; the concept was introduced at 70s & 80s

(i) the compound(s) should be absent or at least at low levels in the food product

(ii) should increase with the storage

(iii) should be produced by the dominant flora and have good correlation with organoleptic testing results.

Outcome's availability; 2-6 hours

[Jay 1973; McMeekin 1976; Gill 1976; Jay, 1986, Nychas et al. 1988; Dainty 1996]

TOOLS

Mathematical modelling

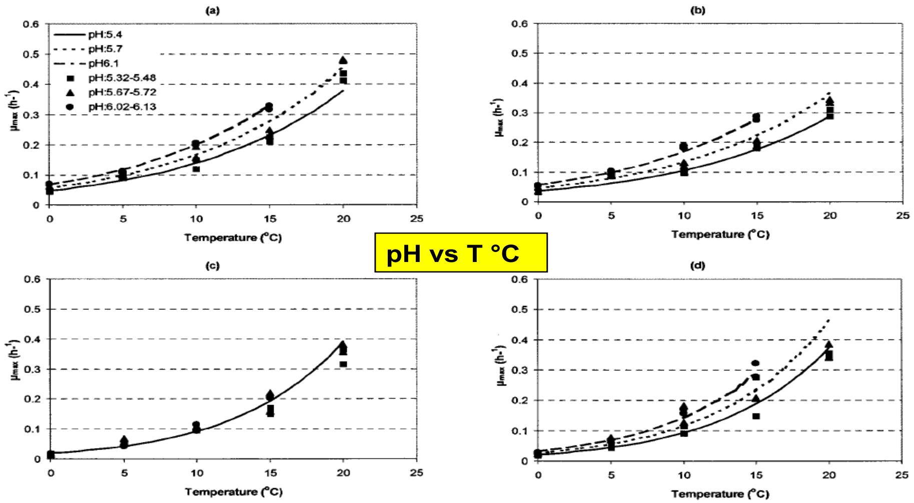
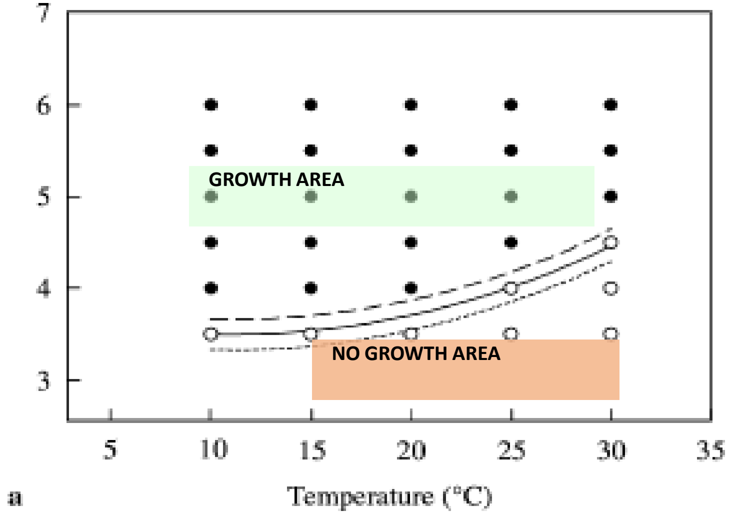


FIG. 4. Predictions of the modified Arrhenius model (equation 1) for the effect of temperature and pH on the maximum specific growth rate (μ_{max}) of the different spoilage bacteria (a, pseudomonads; b, *Brochothrix thermosphacta*; c, lactic acid bacteria; d, *Enterobacteriaceae*) on ground meat. Lines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



Predictive software

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

Mathematical models

Database / libraries

Limitations

- Sensory analysis (expensive, time-consuming)
- Conventional microbiology (Results in 2-3 DAYS)
- Molecular tools (results in 18-30 HOURS)
- Single (bio-chemical metabolite) compound [not feasible]
- Modelling; Few public free and private software are available [Initial population should be known (measurements take 18 to 72 h)]

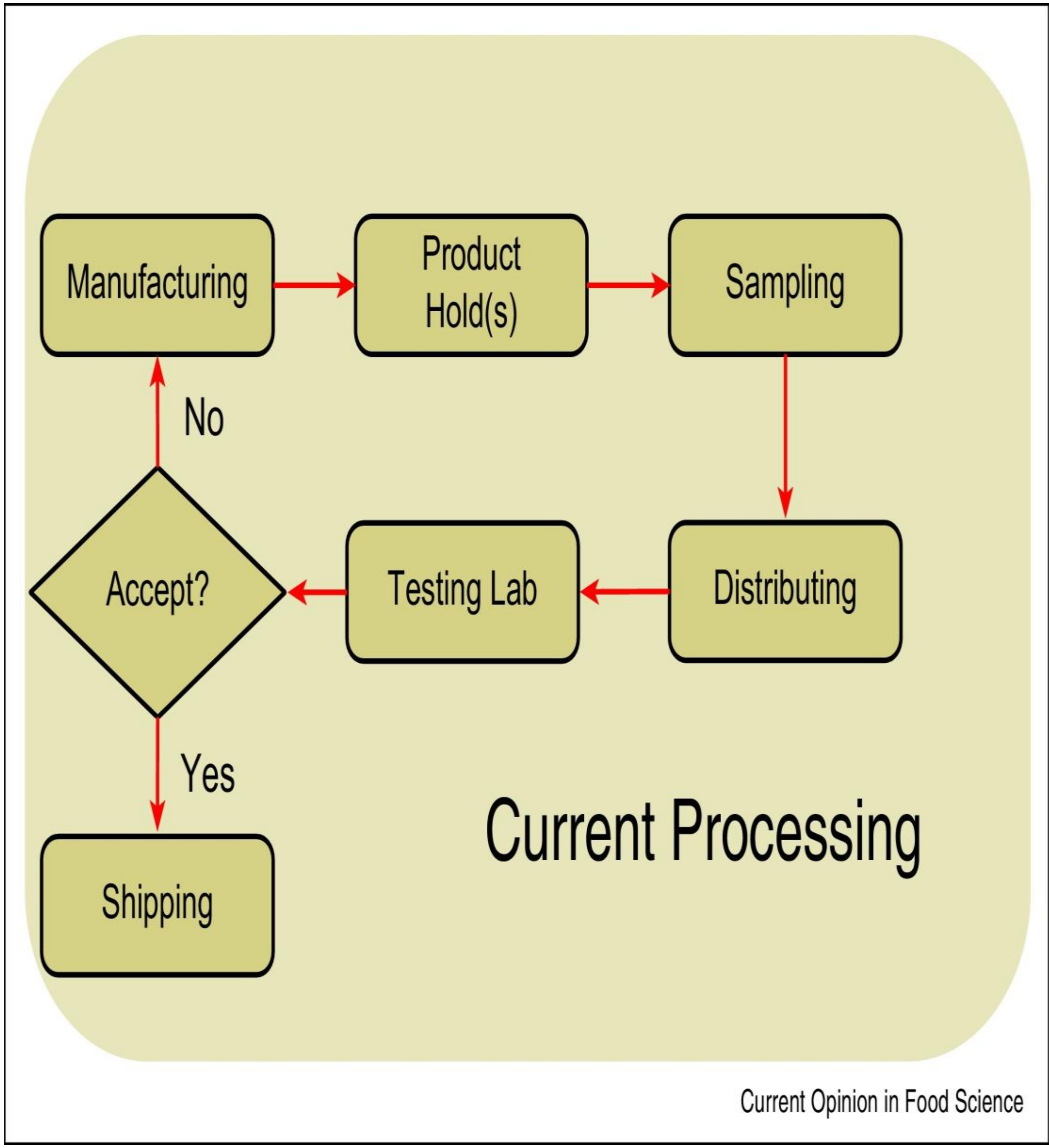
Food Industry, Food Authorities and consumers need results in minutes, if not in seconds!!!

WEBINAR's STRUCTURE

- **Current and Next Generation Strategies**

Current Food Safety Management System

The (whole) production process is based on the analysis of THE END / FINISHED product.



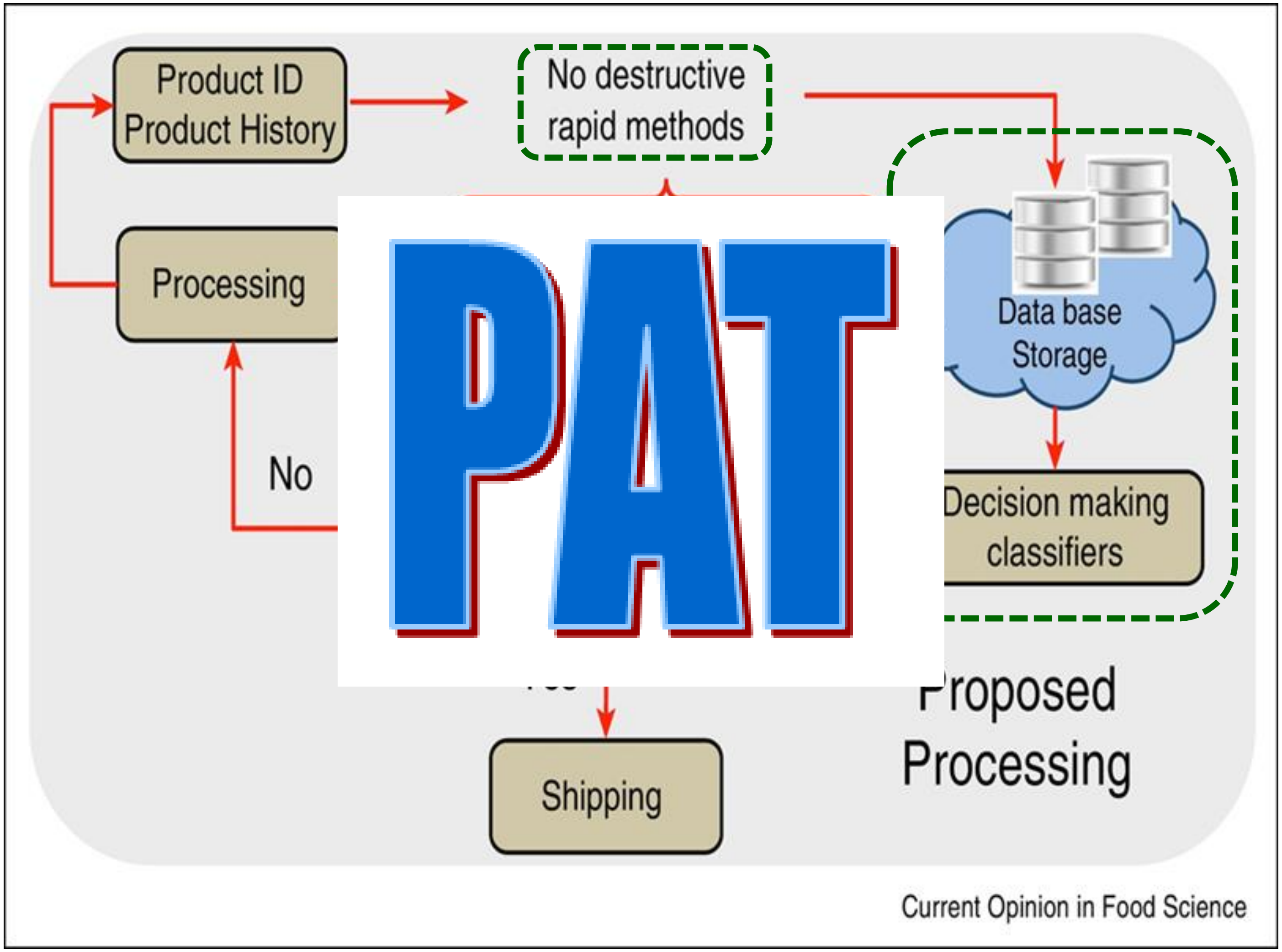
Nychas et al., 2016, Curr. Opin. Food Sci. 12: 13–20

Current Food Safety Management System

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, ng/g)
K098	cream	*Listeria monocytogenes*	55
B079	fish	biogenic amines	17,35
L345	olives	Salty	4

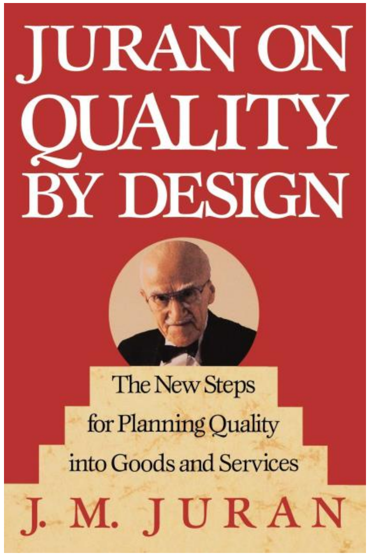
Next Generation Strategies …



Nychas et al., 2016, Curr. Opin. Food Sci. 12: 13–20

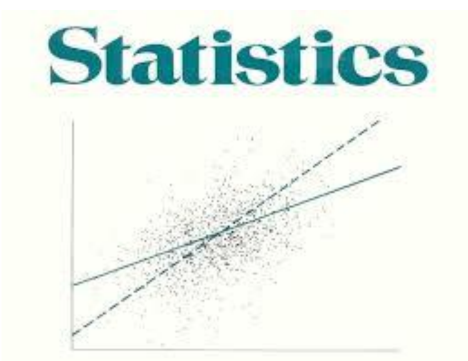
Introduction to Process Analytical Technology (PAT)

- Basis for the concept of "**Quality by Design**" **(QbD)**
- Processing industries: focus on **quality**
- Transition from post-manufacturing checks to the planned <u>integration of quality in processes</u>
- Adherence to quality specifications
- Joseph M. Juran: quality <u>can be planned and designed</u>
- Fundamental application steps of **QbD** in production:
  1. Identification of critical quality parameters
  2. Process design
  3. Control strategies (process performance consistency)
  4. Process validation and documentation/archiving (control strategies' effectiveness)
  5. Continuous monitoring (throughout products' shelf life)



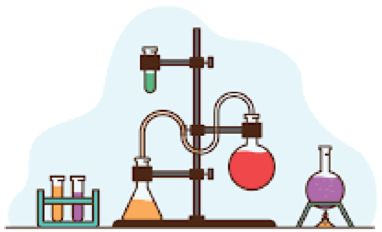
Introduction to Process Analytical Technology (PAT)

- **QbD:** <u>holistic systematic</u> approach in which predefined <u>specifications, processes and critical parameters</u> are taken into account in quality control



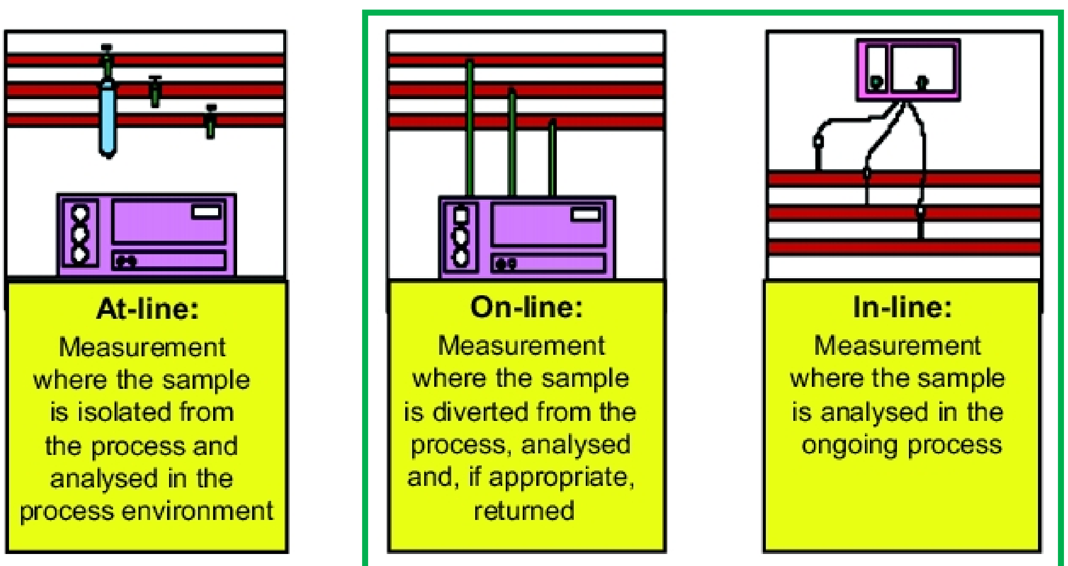
Introduction to Process Analytical Technology (PAT)

- Process Analytical Chemistry (**PAC**): chemical & petrochemical industries
- Pharmaceutical industry **(PAF)**: United States Food and Drug Administration (FDA), 2004



Application of PAT in the Food Industry

- **Objective:** assurance of the desired end-product quality in an <u>efficient</u>, <u>traceable</u> and <u>environmentally friendly</u> manner
- Basis for PAT implementation: development of new sampling methods and "tools" which allow for on time (and real-time) measurements of critical quality parameters (among others…)
- Single and complete system for on-line/in-line measurements of physical, chemical and biological (microbiological) parameters



Nychas et al., 2016, Curr. Opin. Food Sci. 12: 13–20

Tools of Process Analytical Technologies (PAT)

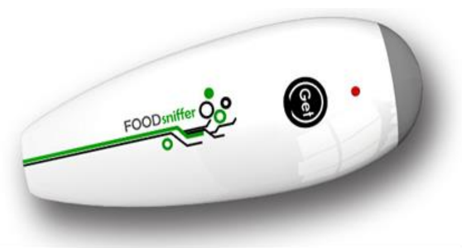
- Sensors; In – On – At line analytical instruments to measure parameters
- Next Generation Sequencing
- Data Science; Data Analytics, Data mining, Machine Learning
- Information Communication Technology

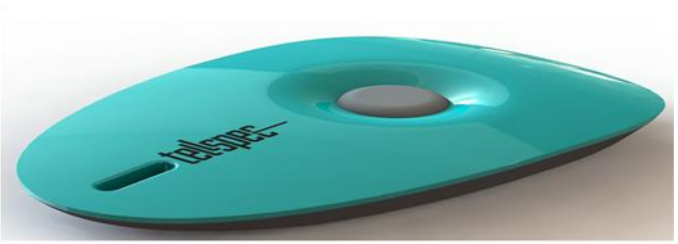
PAT's Tools; Sensors

In – On –At line n*on-invasive analytical technologies (desktop, handheld, miniaturized) based on spectroscopy and/or image analysis *to measure quality & safety parameters

PAT's Tools; sensors con/ed

In – On –At line n*on-invasive analytical technologies (desktop, handheld, miniaturized) based on spectroscopy and/or image analysis *to measure quality & safety parameters





PAT's Tools; sensors con/ed

List of representative rapid methods e.g. Imaging, Spectroscopy and e-nose applied in various food type which their measurement is 'translated' into food quality parameters

Type of Sensor	Food Type	Purpose
Imaging	Beef fillets, Salmon, Mushrooms, Meat, Milk powders, Pork, beef, Prawn, Chicken fillets, Packaged beef, Beef and horsemeat (minced), Narrow-leaved oleaster, Honey	Spoilage, botanical origin, adulteration (horse), meat colour, pseudomonads, microbial counts
Spectroscopy	Animal origin foods: beef, pork, lamb, pork, poultry, **fish,** turkey, Milk, Edible oils, mango, Barley, chickpea and sorghum, Green salads, Chinese tea, coffee, rice, avocado	Spoilage/sensory, Fatty acid & phenol, authentication Detection of adulteration, Quality control analysis, Cultivar identification, **Assessment of microbial contamination**
e-nose	Table olives, Tomatoes, **Strawberry,** Catfish fillets, Peach, Mangoes	Spoilage/sensory, Detection of microbial contamination, **Detection of fungal disease,** Firmness, sugar content, acidity Ripeness/ maturity, Discrimination among processing approaches

Ropodi et al. Trends in Food Sci. & Techn. 50,11-25

PAT's Tools; NGS

Application of NGS in food safety

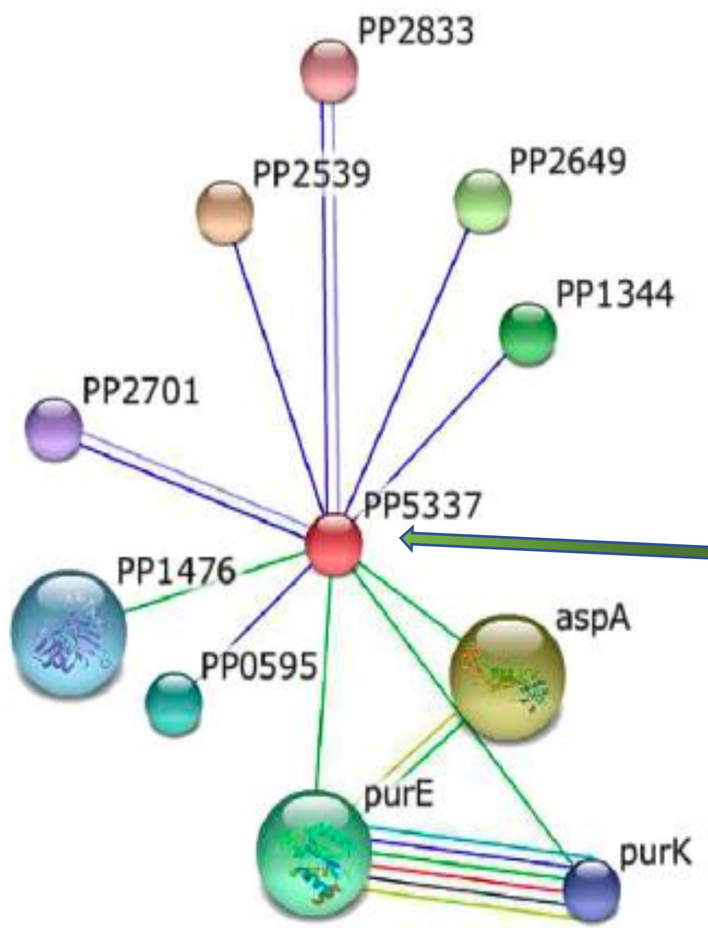
- Recent advances in sequencing technologies over the past decade have given an unprecedented opportunity to enhance our understanding of the microbial behaviour on a molecular level across all -omics levels.

- To date, the application of next-generation sequencing technologies (NGS) in food quality and safety has been limited to retrospective identification and traceability, such as determining authenticity of imported food goods, and identifying food contamination following an outbreak.

den Besten et al. 2018 IJFM 287, 18-27 Cocolin et al. 2018 IJFM 287, 10-17

PAT's Tools; NGS

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



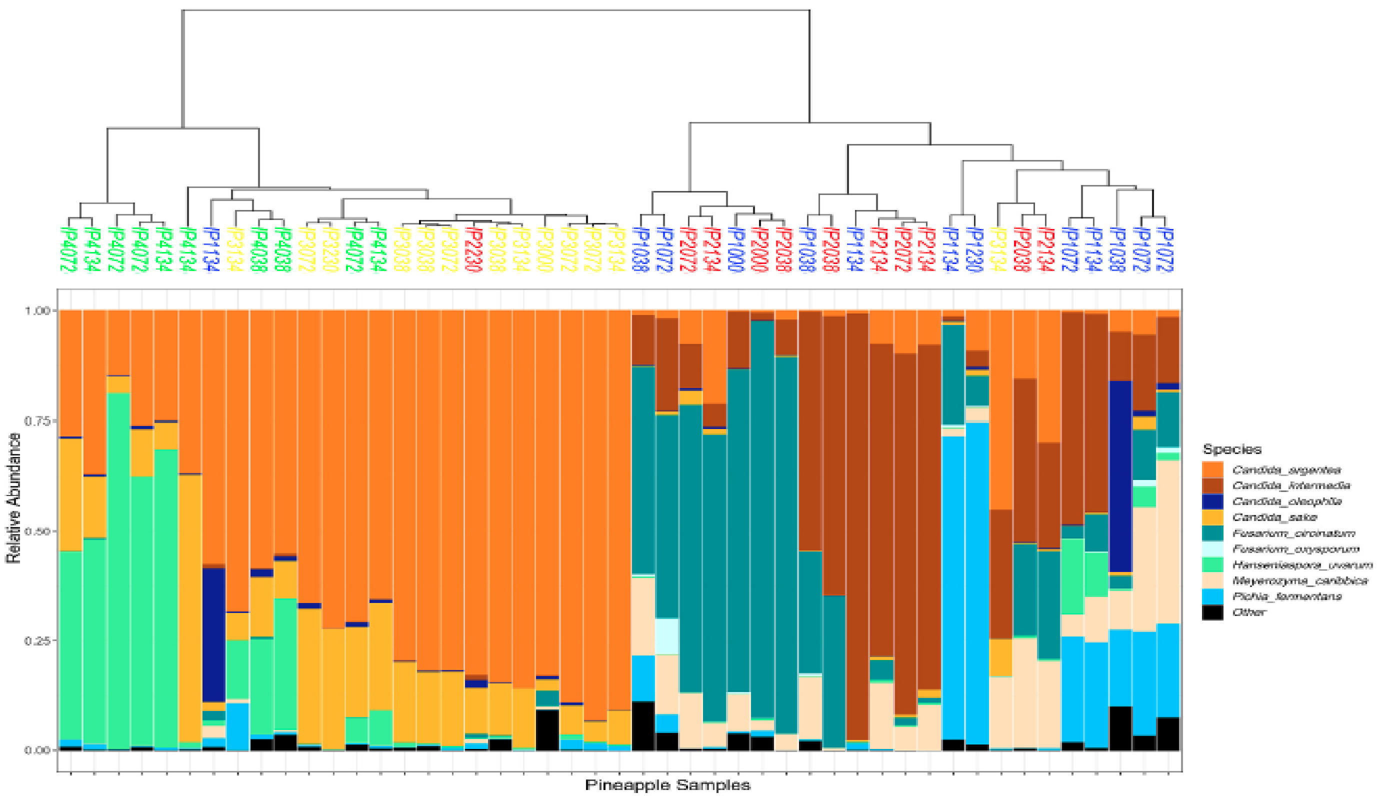
Gene "PP5337"

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

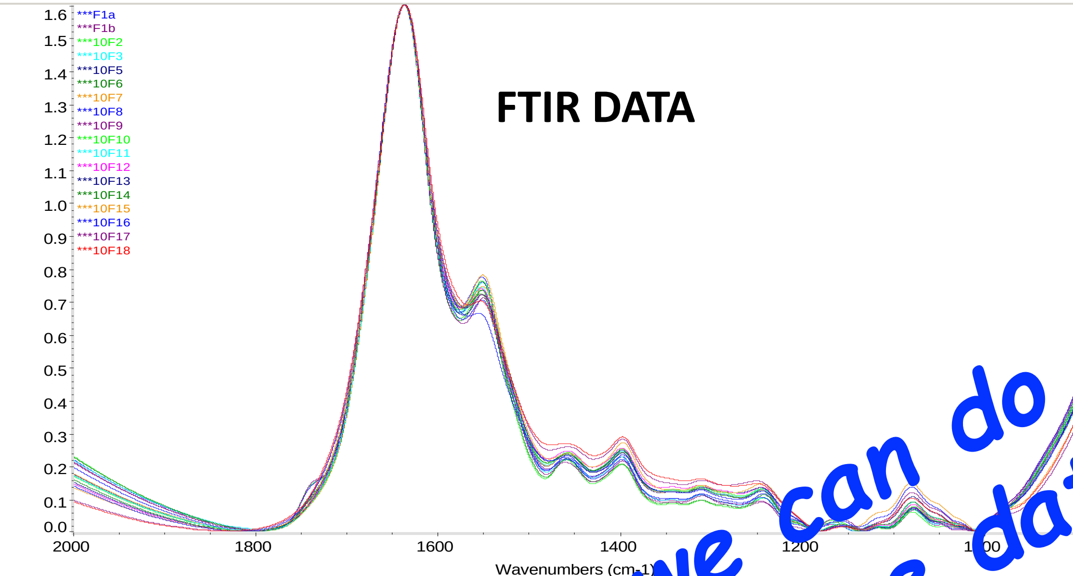
PAT's Tools; NGS

Metagenomics provides an excellent framework for studying the microbial ecosystem through monitoring the relationships between different species and their interaction to identify the impact of some naturally occurring or spoiling species on the presence, growth suppression, or activation of pathogens. Furthermore, the interaction between the food matrix and the environmental conditions during storage and their impact on the microbial ecosystem can be monitored across several products such as cheese, vegetables, meat and poultry.



Composition plot showing the relative abundances of the nine main Ascomycota species found in Pineapples samples (Manthou et al 2021 Int. J. Food Micro)

PAT's Tools; Data Science



HPLC DATA

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162172	0	17278	16288	90968	2052876	528128	0	27784	101539	545549.75	8639	199389
117525	12199	9998	1087	59267	1698282	388386	0	19496	113097	457718.75	11098.5	141566.3
163032	123717	383448	16240	155697	2502703	182667	0	52040	43730	649618.25	253582.5	129409
110482	149360	216311	17312	103662	1787944	108295	4613	34377	17436	461092.5	182835.5	84937.75
115580	9329	17818	28913	116854	693017	[illegible]	[illegible]	[illegible]	48707	207109.25	13573.5	127350
62182	0	50632	17240	71473	[illegible]	[illegible]	[illegible]	[illegible]	136613	193902	25316	160097.8
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119447	2657	13319	11497	[illegible]	1916881	735624	0	13948	93442	506067.75	7988	248402.5
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26770	67715	74895	[illegible]	[illegible]	1475829	565796	45536	81817	48695	412969.25	71305	178670.5
42167	[illegible]	61994	[illegible]	[illegible]	519290	370630	42109	233320	121497	229054	41718	150459.5
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139184	32041	155572	15000	108229	1939082	650000	45903	59927	39578	521122.5	93806.5	228103.3
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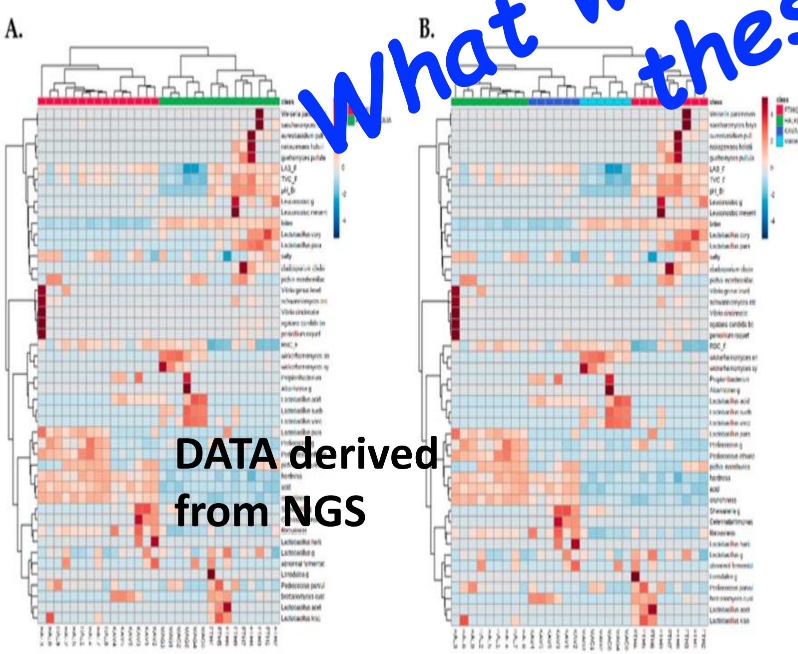
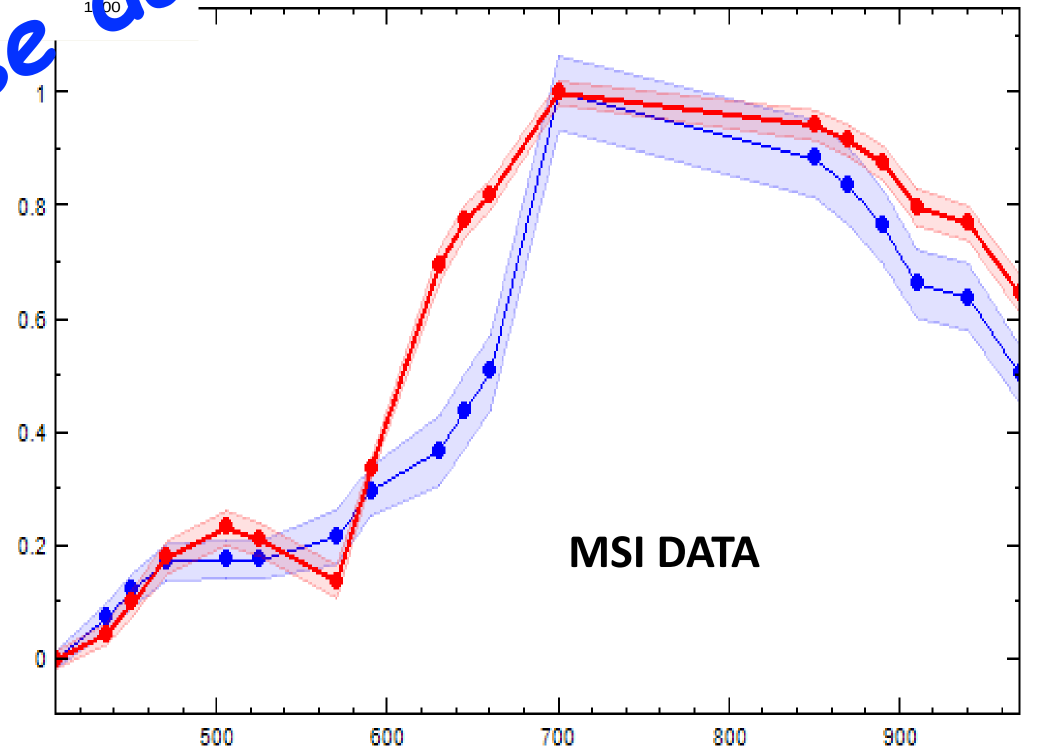


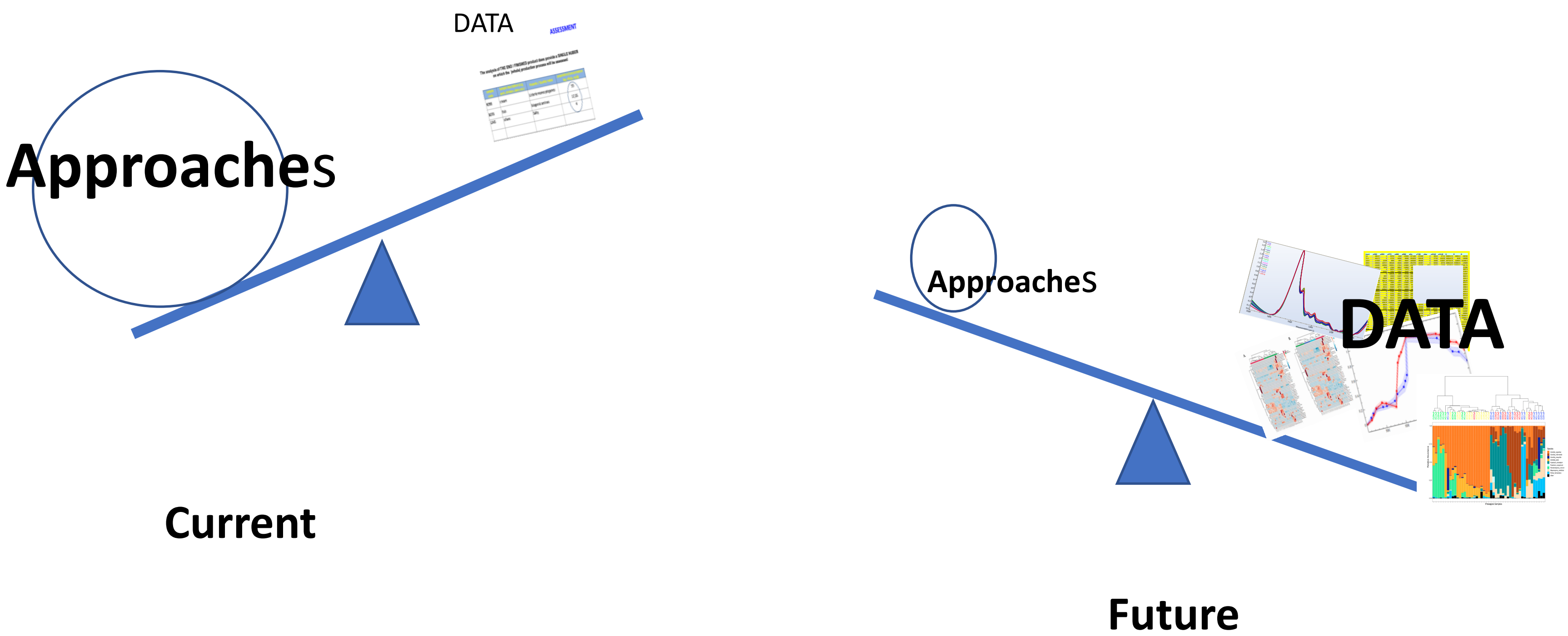


What we can do with all these data

PAT's Tools; Data Science

Data mining, Data analysis, Machine Learning

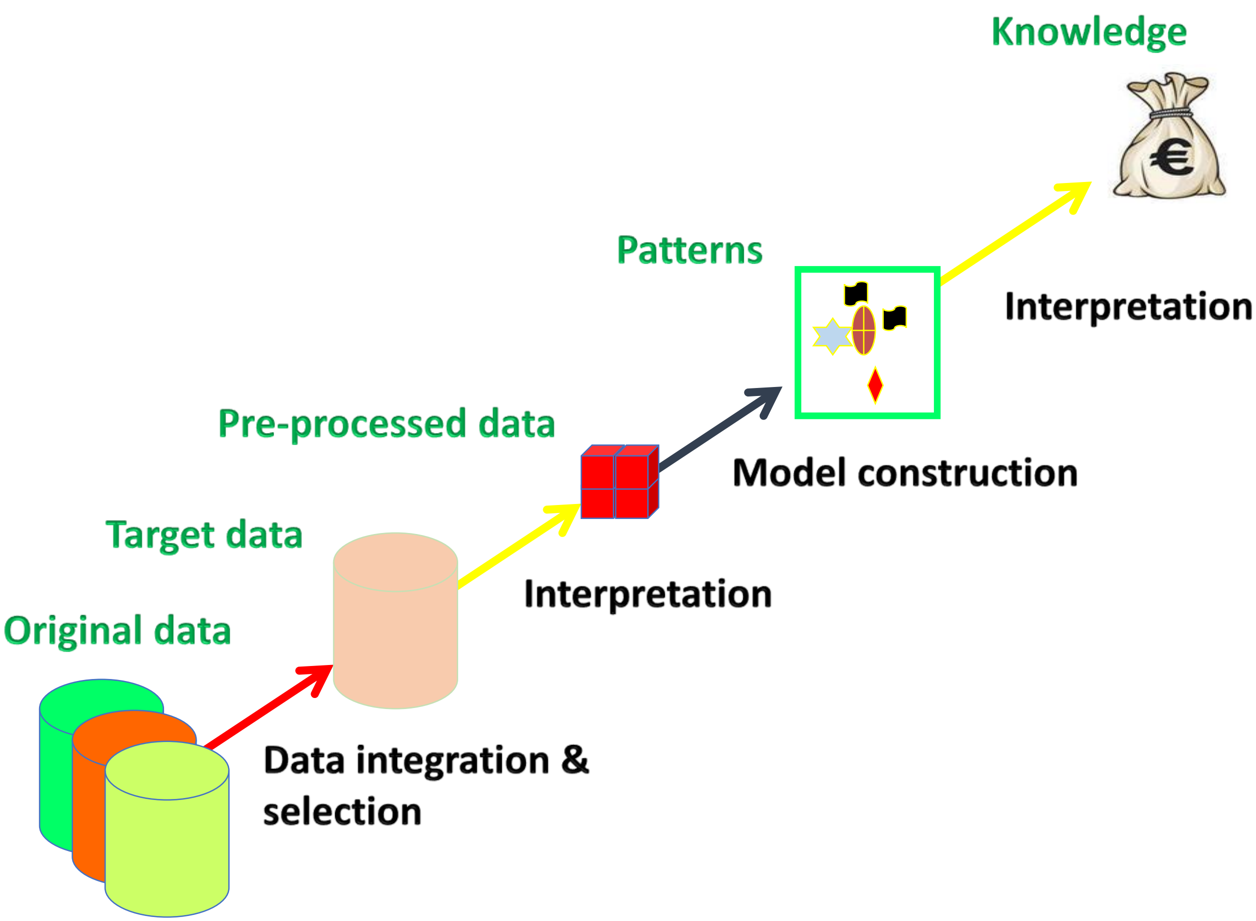
- The massive amount of data generated by various analytical and high throughput platforms is a challenging issue for food safety.

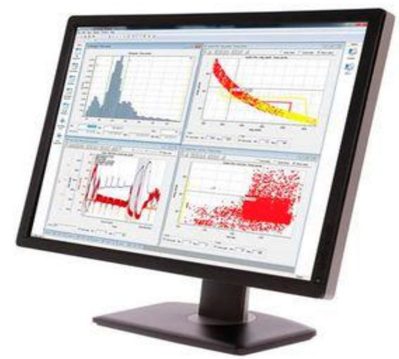


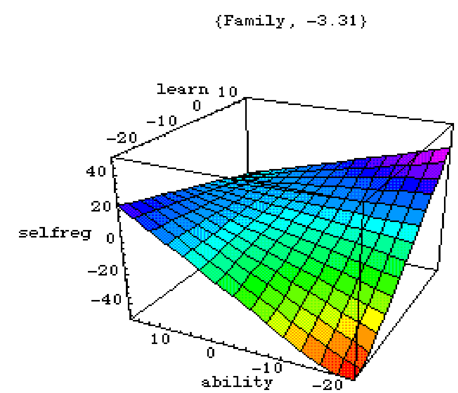
Nychas et al. 2021 An. Rev Biomedical Data Sci. (in Press)

PAT's Tools; Data Science

Data Mining, Data Analytics, Machine Learning







PAT's Tools; Data Science

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.

Data Acquisition	Data Analysis	Data Curation	Data Storage	Data Usage
• Structured data	• Stream mining	• Data Quality	• In-Memory DBs	• Decision support
• Unstructured data	• Semantic analysis	• Trust / Provenance	• NoSQL DBs	• Prediction
• Event processing	• Machine learning	• Annotation	• NewSQL DBs	• In-use analytics
• Sensor networks	• Information extraction	• Data validation	• Cloud storage	• Simulation
• Protocols	• Linked Data	• Human-Data Interaction	• Query Interfaces	• Exploration
• Real-time	• Data discovery	• Top-down/Bottom-up	• Scalability and Performance	• Visualisation
• Data streams	• 'Whole world' semantics	• Community / Crowd	• Data Models	• Modeling
• Multimodality	• Ecosystems	• Human Computation	• Consistency, Availability, Partition-tolerance	• Control
	• Community data analysis	• Curation at scale	• Security and Privacy	• Domain-specific usage
	• Cross-sectorial data analysis	• Incentivisation	• Standardization	
		• Automation		
		• Interoperability		

Technical Working Groups

Curry, E., Ngonga, A., Domingue, J., Freitas, A., Strohbach, M., Becker, T., et al. (2014). D2.2.2. Final version of the technical white paper. Public deliverable of the EU-Project BIG (318062;ICT-2011.4.4).

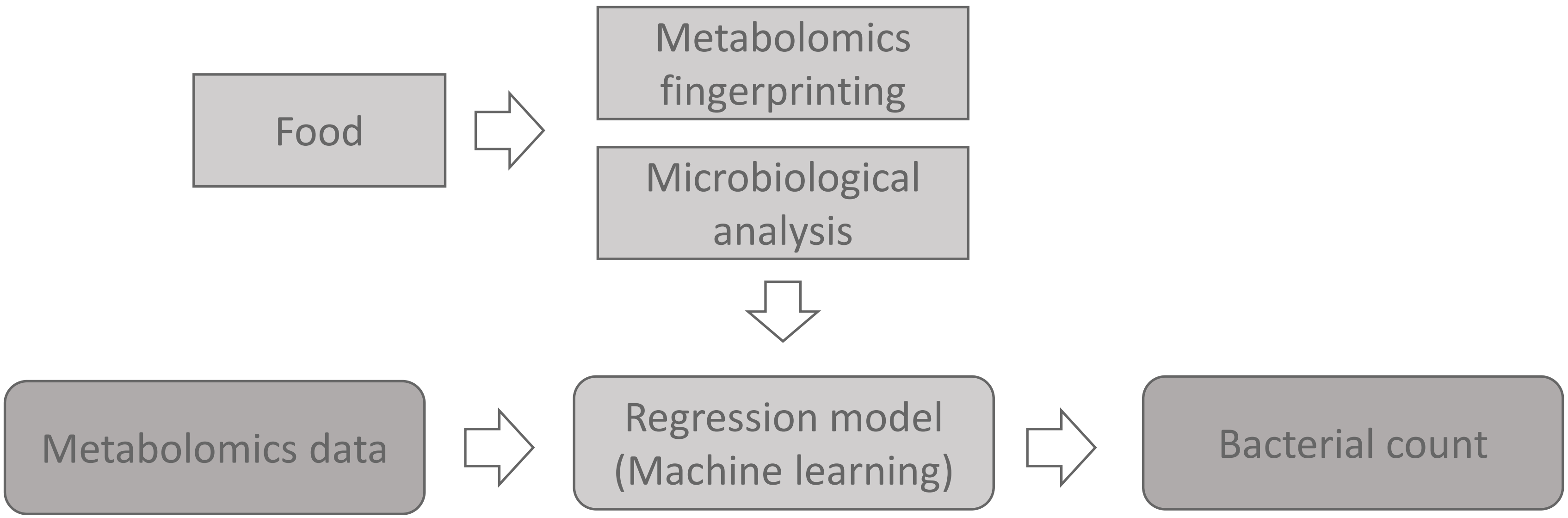
PAT's Tools; Data Science

Data Science; Data mining, Data analysis, Machine Learning

products	purpose	data analysis

Type of Sensor	Food Type	Purpose
Imaging	Beef fillets, Salmon, Mushrooms, Meat, Milk powders, Pork, beef, Prawn, Chicken fillets, Packaged beef, Beef and horsemeat (minced), Narrow-leaved oleaster, Honey	Spoilage, botanical origin, adulteration (horse), meat colour, pseudomonads, microbial counts
Spectroscopy	Animal origin foods: beef, pork, lamb, pork, poultry, **fish**, turkey, Milk, Edible oils, mango, Barley, chickpea and sorghum, Green salads, Chinese tea, coffee, rice, avocado	Spoilage/sensory, Fatty acid & phenol, authentication Detection of adulteration, Quality control analysis, Cultivar identification, **Assessment of microbial contamination**
e-nose	Table olives, Tomatoes, **Strawberry,** Catfish fillets, Peach, Mangoes	Spoilage/sensory, Detection of microbial contamination, **Detection of fungal disease**, Firmness, sugar content, acidity Ripeness/ maturity, Discrimination among processing approaches

Combining analytical instruments (metabolomics) & machine learning



- The use of metabolomics analytical platform in tandem with machine learning allows to assess the freshness of food samples.

Combining analytical instruments (metabolomics) & machine learning

- **Microbiological spoilage experiments**

Minced pork

Packaged in ***modified atmospheres*** (80% O_2-20% CO_2) and stored at:

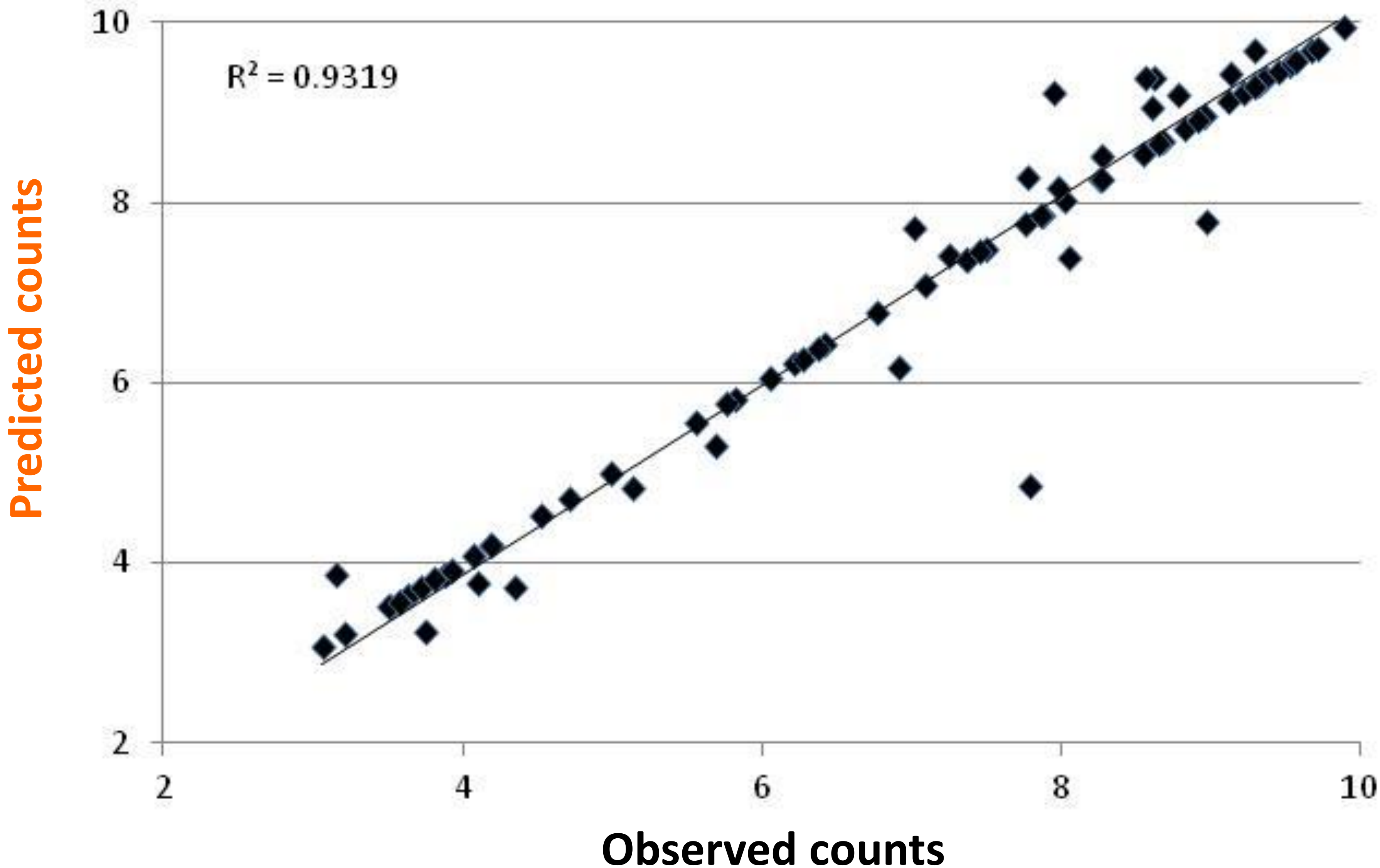
- ***Isothermal*** conditions (4, 8, 12°C)
- ***Dynamic temperature*** conditions (periodic temperature changes between 4 and 12°C)

4 batches
431 samples

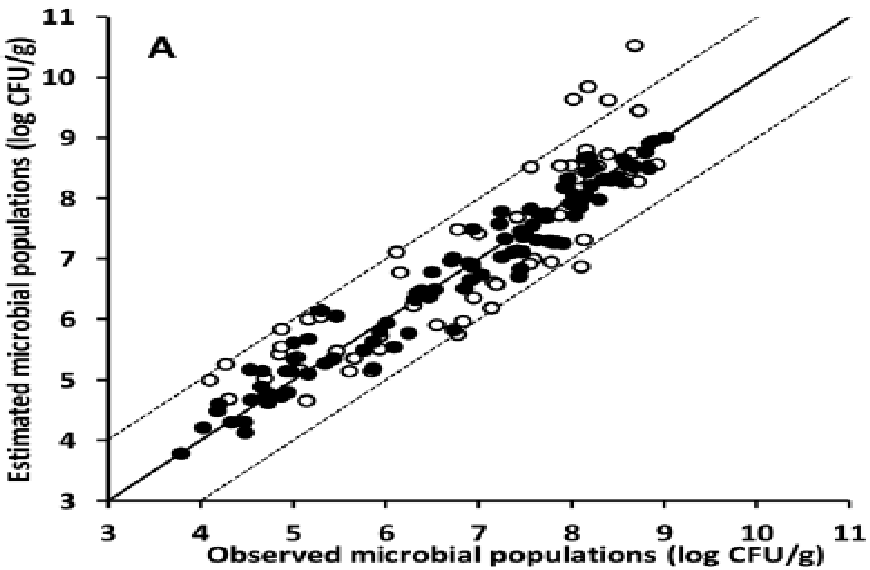
Microbiological analysis

VideometerLab/ FTIR

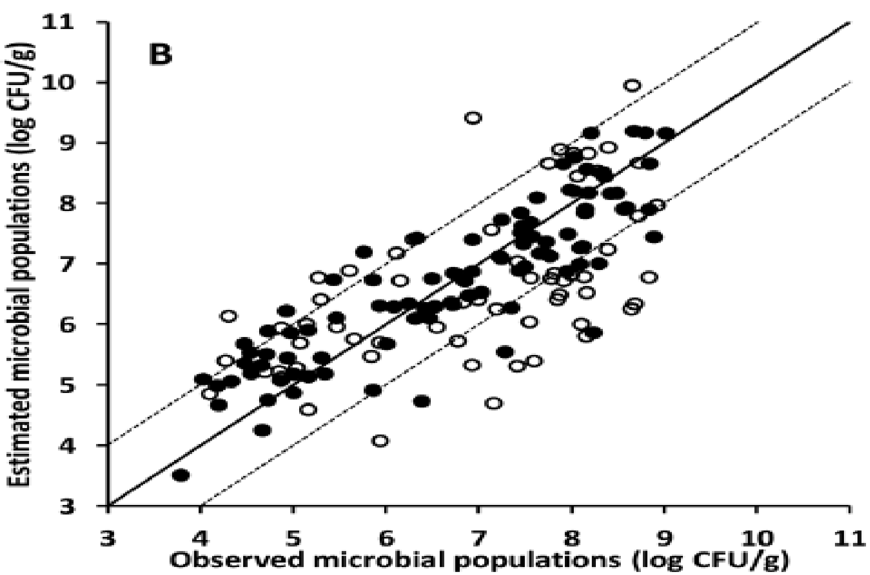
BEEF FILLETS; MSI measurements; Comparison between observed and predicted total viable counts (TVC) by ANNs



FARMED SEA BREAM; FTIR Comparison between observed and predicted total viable counts (TVC) of skin (A) and flesh (B)



Data for the calibration (solid symbols) and the prediction (open symbols) data sets (solid line: the ideal **y**=**x** line; dashed lines: the ±1 log unit area).



Fengou et al (2019), Food Microbiol. 79, 27-34

PAT's Tools; Data Science

Data Science; Data mining, Data analysis, Machine Learning

List of various MATLAB, R and python libraries available for chemometric and machine learning applications [modified from Ropodi et al 2016)].

	Libraries	Methods
Matlab **www.mathworks.com**	Statistics and Machine Learning Toolbox, Neural Network Toolbox , PLS Toolbox, LibPLS, iToolbox, PLS-Genetic Algorithm Toolbox, libSVM, LS-SVMlab	HCA, k-means, ANOVA, MLR, LDA, kNN, SVM, RF and other methods, ANNs, MLR, PLS, PCR and preprocessing methods , PLS-R & -DA, LDA and various methods for preprocesing, variable selection and outlier detection, PLS variants with intervals (iPLS, BiPLS, FiPLS, SiPLS,mwPLS)
R www.r-project.org	**The R Stats Package, chemometrics,chemometricsWithR, Pls, plsgenomics, gpls, cluster, Neuralnet, e1071, randomForest, Gbm, robustbase, FNN, tidyverse, BLR, Ranger**	**HCA, PCA, k-means and other Statistics' functions SVM (libSVM) and other clustering methods Data Visualisation**
Python https://pypi.org/project/	**NumPy, Pandas, Matplotlib, Scikit-learn, Scikit-image, Keras**	**Array Computing, Flexible data structures, Data visualization, Comprehensive regression and classification model suite, Image edge detection and segmentation, Deep Neural Networks**

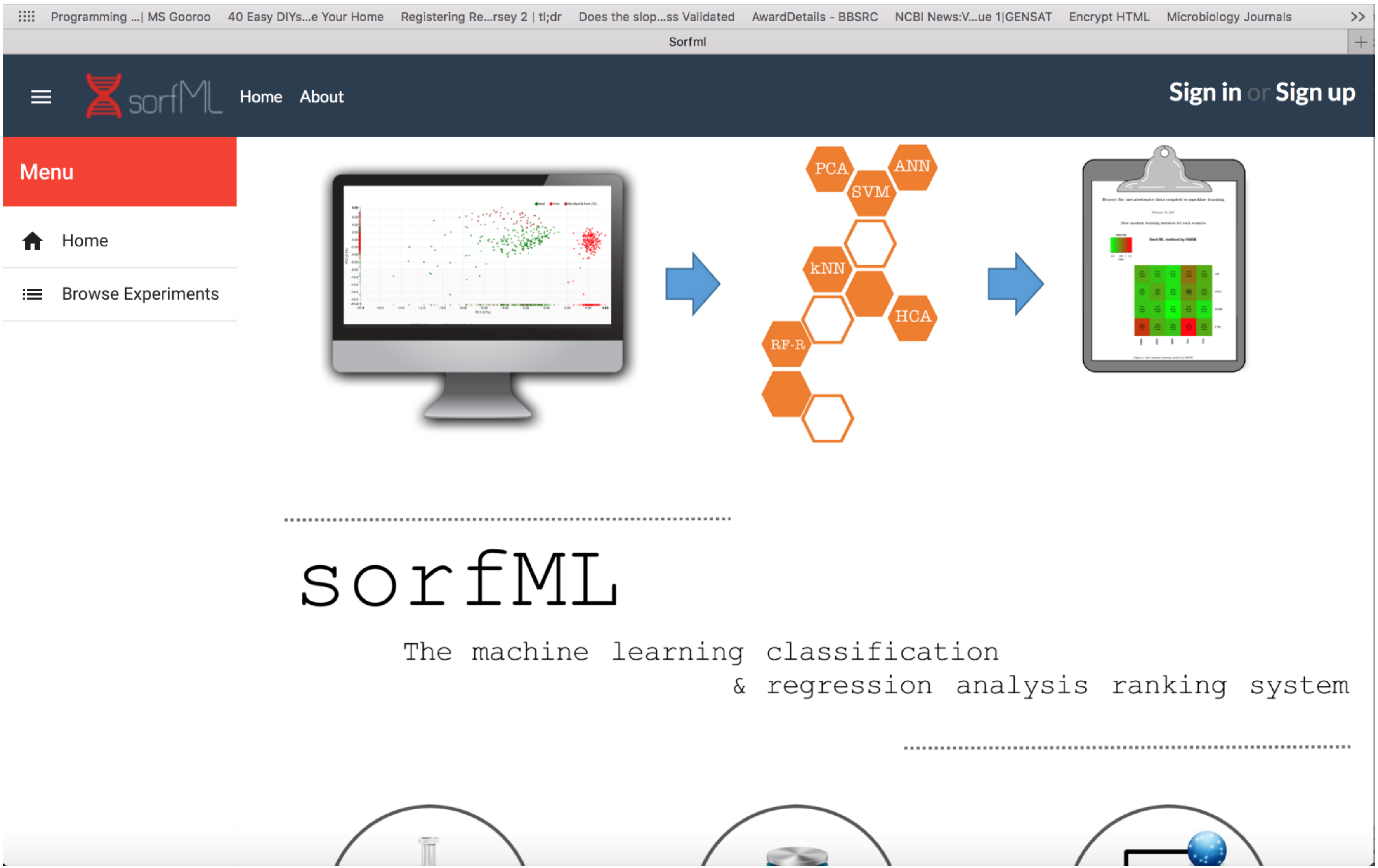
Online food safety database & toolboxes for food analytics

Nychas et al. 2021 An.Rev Biomedical Data Sci. (in Press)

PAT's Tools; Data Science

Data Science; Data mining, Data analysis, Machine Learning

sorfML (www.sorfml.com) Symbiosis Online Research Framework Machine Learning



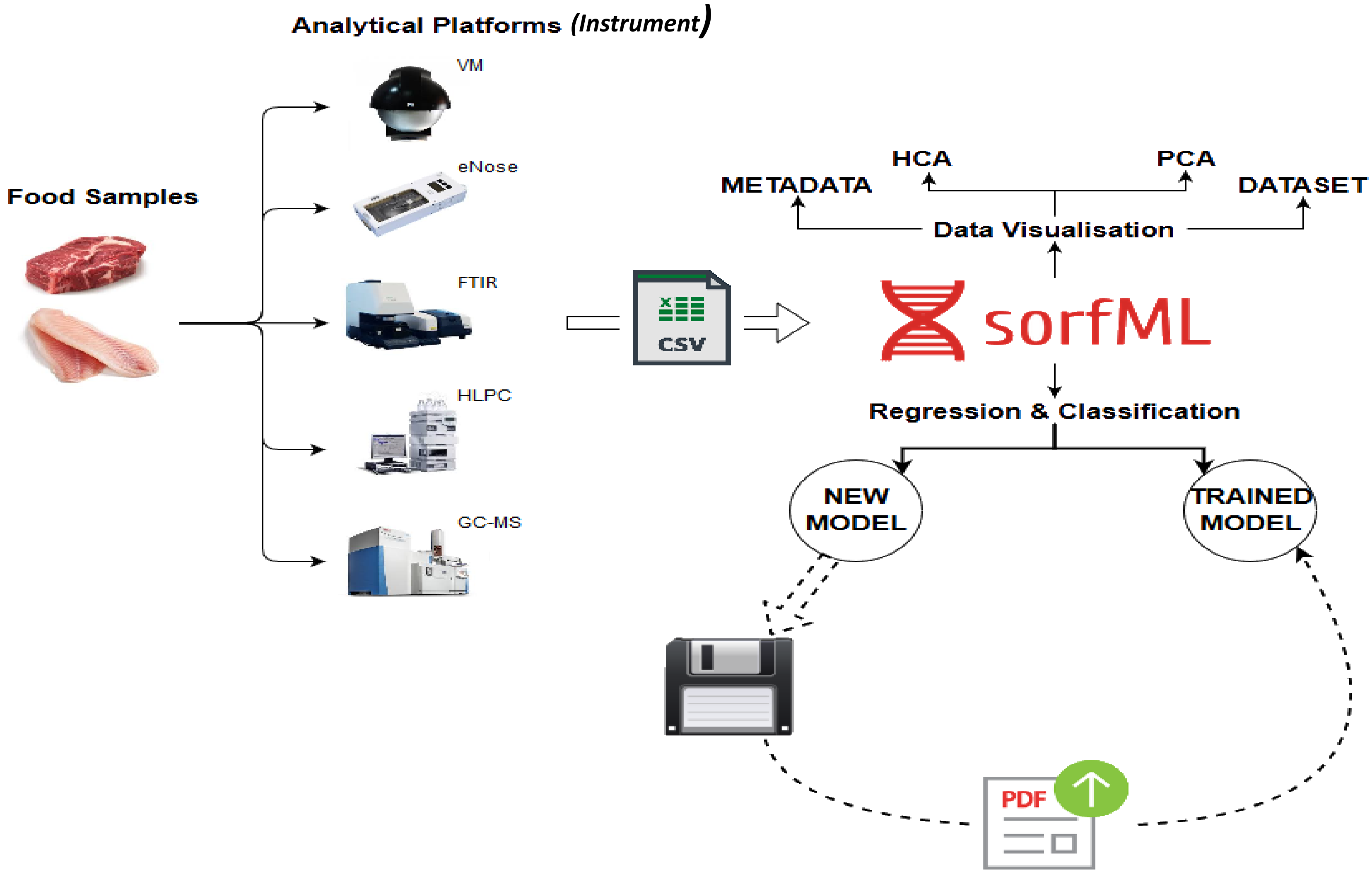
Spyrelli et al. 2021 Cur. Res Fd Sc. 4, 121

Online food safety database & toolboxes for food analytics

PAT's Tools; Data Science

Data Science; Data mining, Data analysis, Machine Learning

sorfML (www.sorfml.com) **Symbiosis Online Research Framework Machine Learning**



Manthou et al. 2020 Com.Elec in Agr. 175,105529

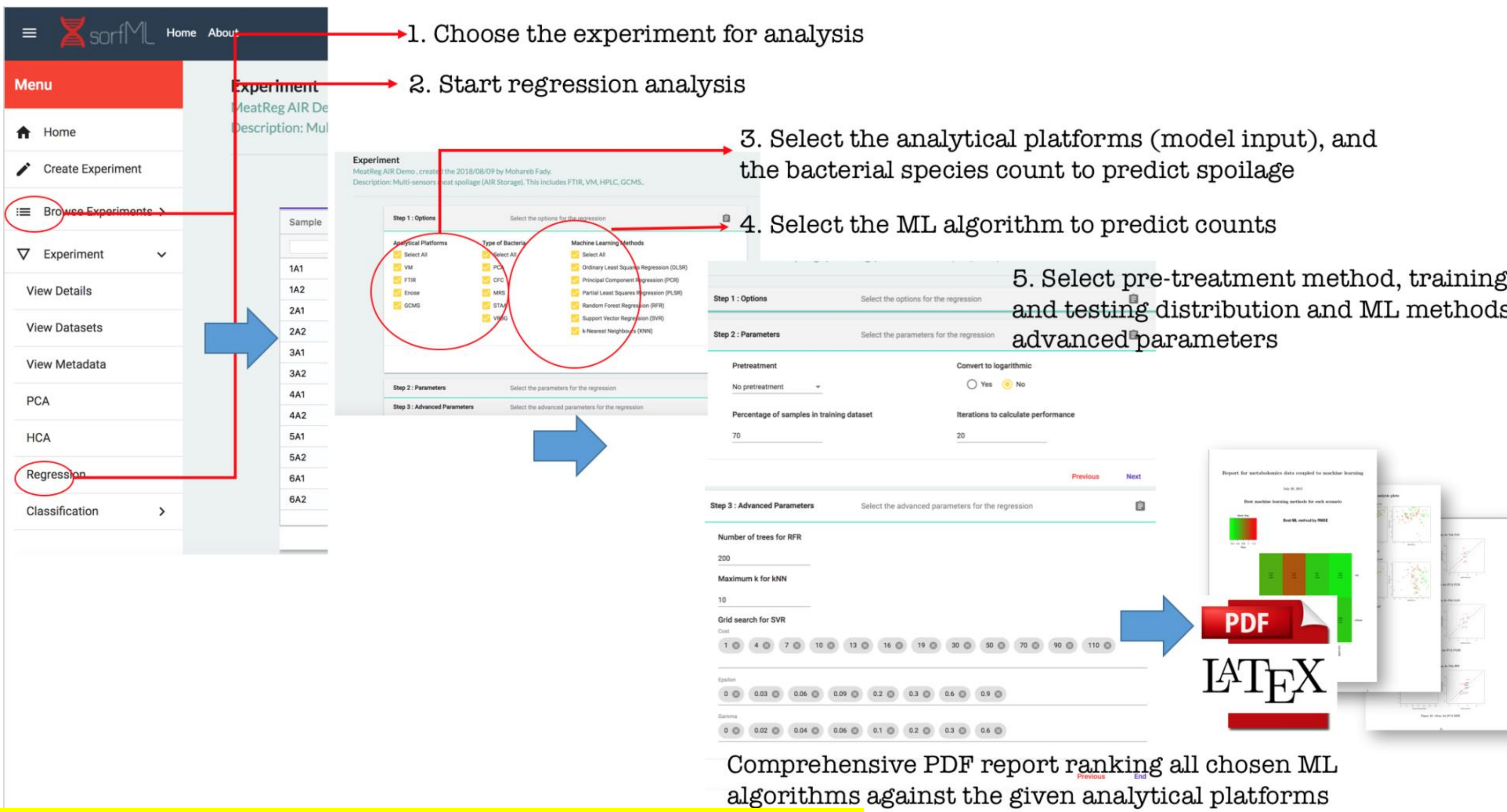
Online food safety database & toolboxes for food analytics

PAT's Tools; Data Science

Data Science; Data mining, Data analysis, Machine Learning

sorfML (www.sorfml.com) **Symbiosis Online Research Framework Machine Learning**

Performing classification and/or regression modelling to predict spoilage



Online food safety database & toolboxes for food analytics

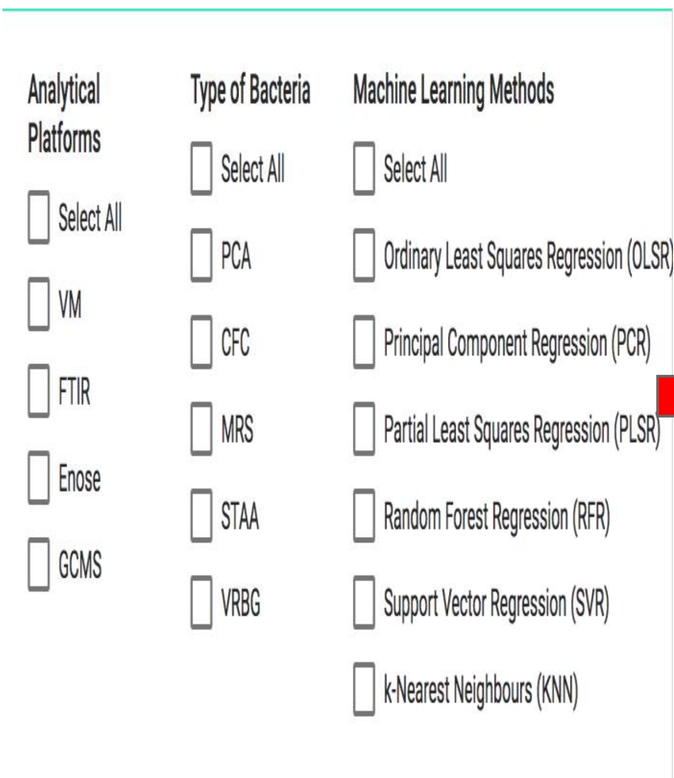
PAT's Tools; Data Science

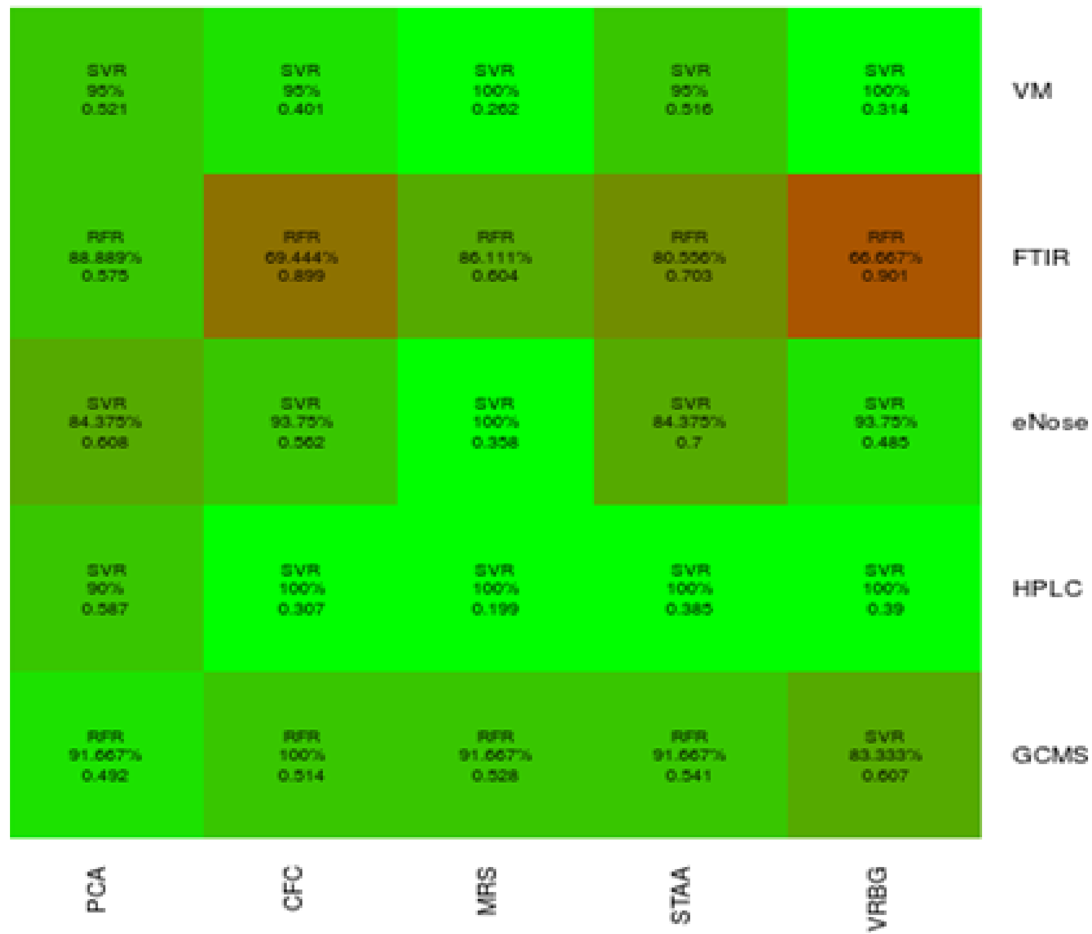
Data Science; Data mining, Data analysis, Machine Learning

sorfML (www.sorfml.com) **Symbiosis Online Research Framework Machine Learning**

- ML analysis report

[Modified atmosphere packaging]()



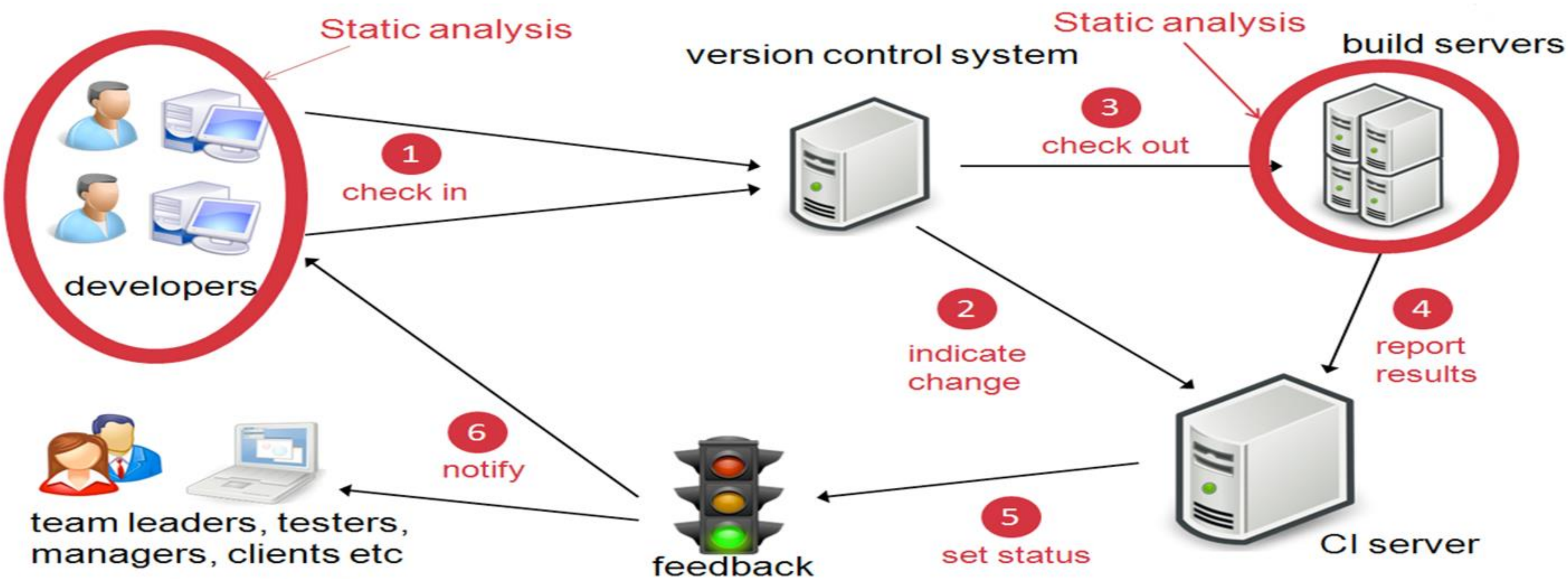


Estelles-Lopez et al. 2017 Food Res Int. 99,206-215

Online food safety database & toolboxes for food analytics

PAT's Tools; ICT

Information/data management and continuous optimization



WEBINAR's STRUCTURE

- Challenges of Data Sciences on food safety and beyond

- **Microbiological spoilage experiments**

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Microbiological analysis

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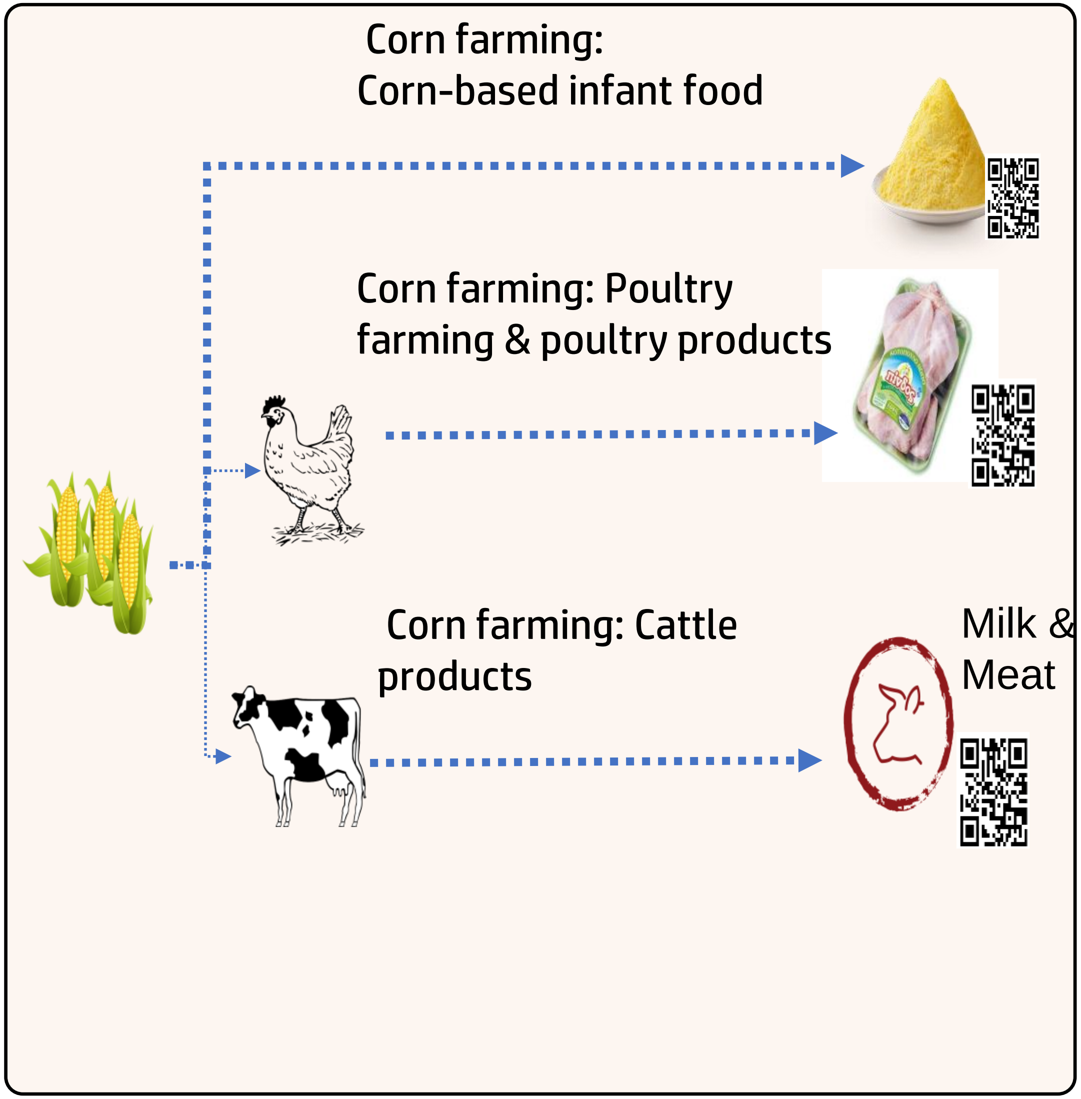
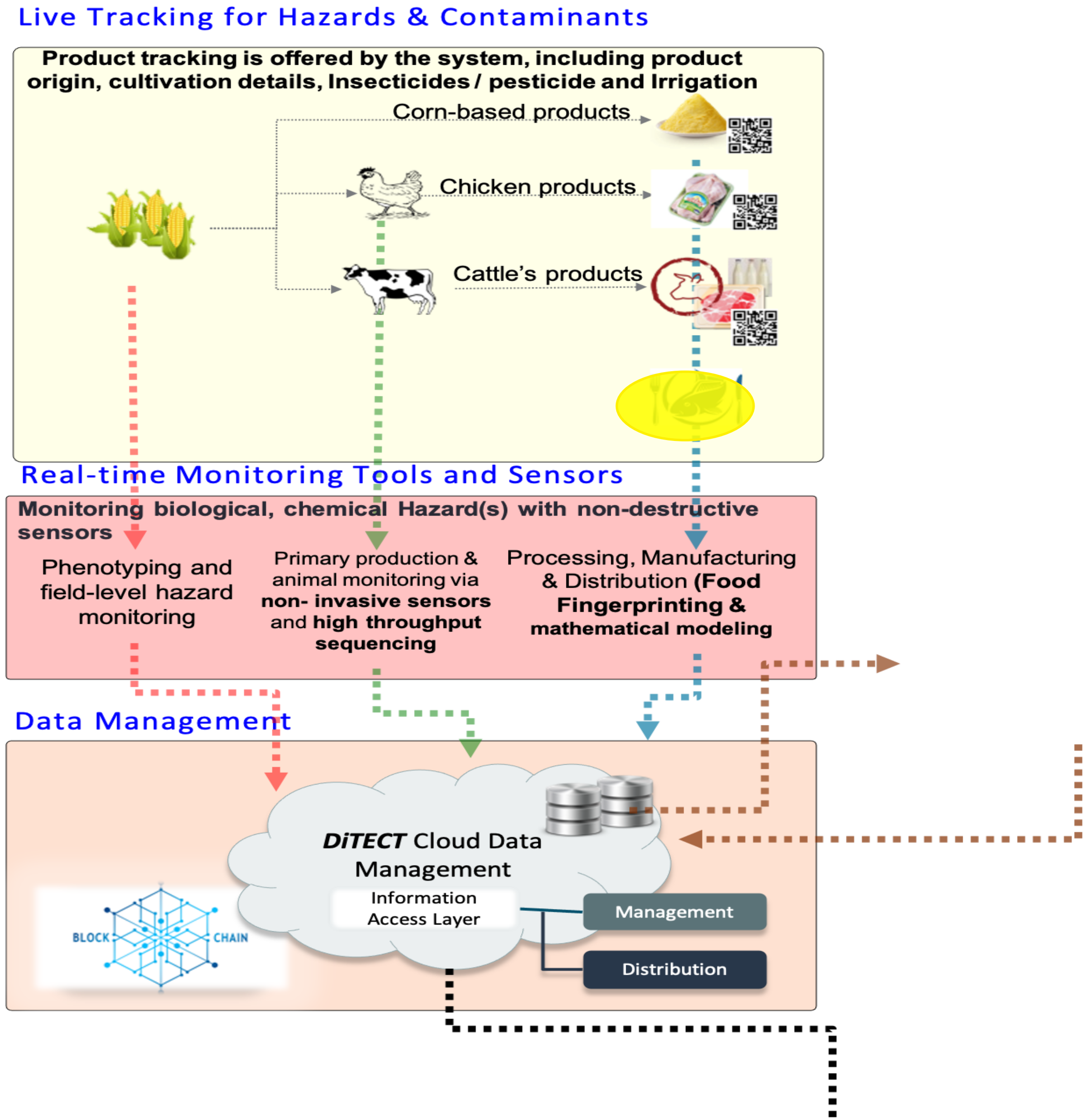
PAT's Tools; Data Science in Food Sector



PAT's Tools; Data Science in Food Sector



DiTECT; EU-CHINA Project

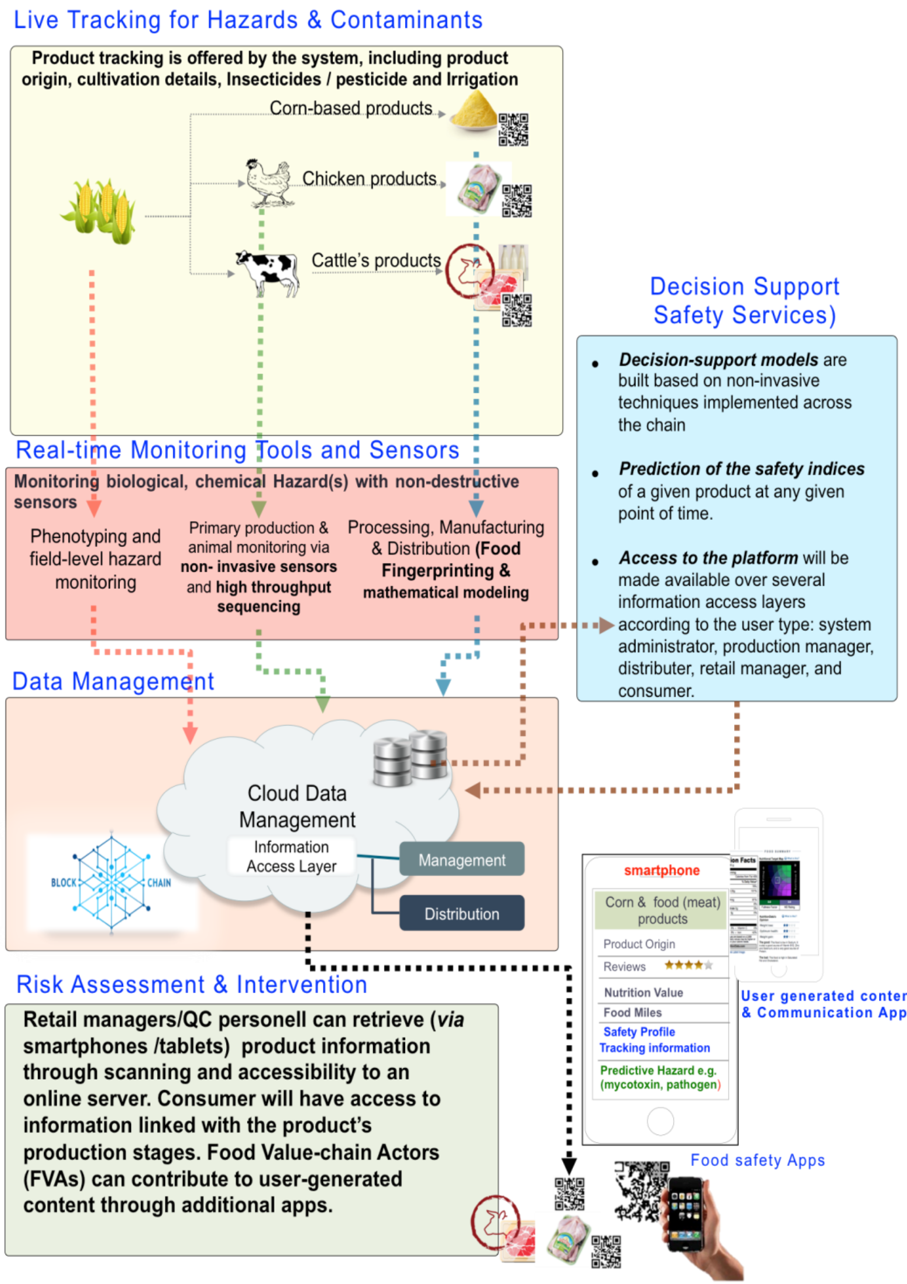
PAT's Tools; Data Science in Food Sector

Critical Issues that should be addressed

- A first critical area that needs to be transformed towards Industry 4.0 for the food sector is the data and information infrastructure that will support open access and data under the **FAIR principles**.

- the **data anonymization and data privacy**; concerns methods development in a way that the data would not be distorted and the context of the original study upheld

- AI & ML coupled with the other **Information Technologies** with data other than those produced in a laboratory, would be used to advance surveillance and alert systems for foodborne outbreaks and diseases



DiTECT; EU-CHINA Project

PAT's Tools; ICT

IcT is simply defined as the use of computing platforms (cloud platforms) and internet-based communication devices and protocols to compute, manipulate, store and retrieve, and communicate (transmit and receive) data and information, mostly for business and community services.

PAT's Tools; ICT

We need a CLOUD ..

DiTECT;* 861915 (H2020-SFS-2019-2) -*DIgital TEChnologies as an enabler for a conTinuous transformation of food safety management system

PAT's Tools; ICT

…. and someone to upload the data ..

PAT's Tools; ICT

…. with a contemporary / modern approach …..

SUMMARY POINTS

- In the pre-Big Data and smart devices age, the food science studies result could be found almost exclusively within the academia, authorities and media.

- The prospect of multiple time points throughout observation of singular samples within the chain will help identify, pinpoint, and analyze current weaknesses in maintaining food safety and quality standards, changing and refining the operations and policy making decisions of food stakeholders, such as food operators, inspectors, and researchers.

- Innovative integrated knowledge repository that covers Big Data from all stages of production to entire food chain that can be accessible globally *via* the cloud database that will accommodate decision making tools – based on product history establishes the basis for a new line of technology predicting food safety.

- The changes that new ICT, IoT and Big Data will bring to food sciences and their stakeholders are much greater than most people can think or estimate, especially with the extremely dynamic advancements in smart devices.

- The users (consumers, authorities, food operators etc.) will not only get the needed recommendations, but also, they will have on-line the tools to fulfil that need.

MEAT; Beef, Pork, Poultry,

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MEAT; Beef, Pork, Poultry,

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DiTECT: Digital Technologies as an enabler for a continuous transforamtion of food safety system. Funded by HORIZON 2020 www.ditect.eu

QAPP; Safety and quality of Fresh Poultry Products; funded by ESPA and EU www.qapp.gr

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Data Science in the Food Industry

THANKS FOR YOUR ATTENTION

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