PRESENTATION

International conference on Food Safety Risk Analysis and Antimicrobial Resistance

Moscow, Russian Federation, 17- 18 12/2019

ПРЕЗЕНТАЦИЯ

Международная конференция по вопросам анализа риска безопасности пищевой продукции и устойчивости к противомикробным препаратам

Москва, Российская Федерация, 17 -18 12/2019

Risk Assessment of Novel Technologies and Novel Foods

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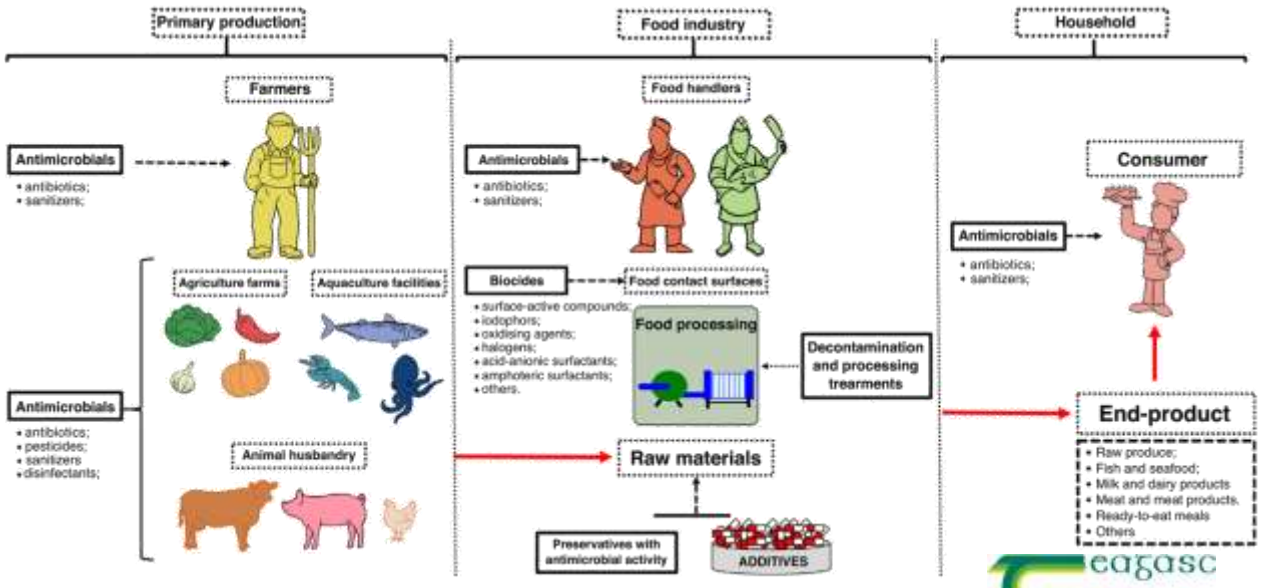
AFT GROUP

teagasc

Teagasc –Agriculture and Food Development Authority

- Animal and Grassland Research and Innovation
- Crops, Environment and Land Use
- Food
- Rural Economy and Development

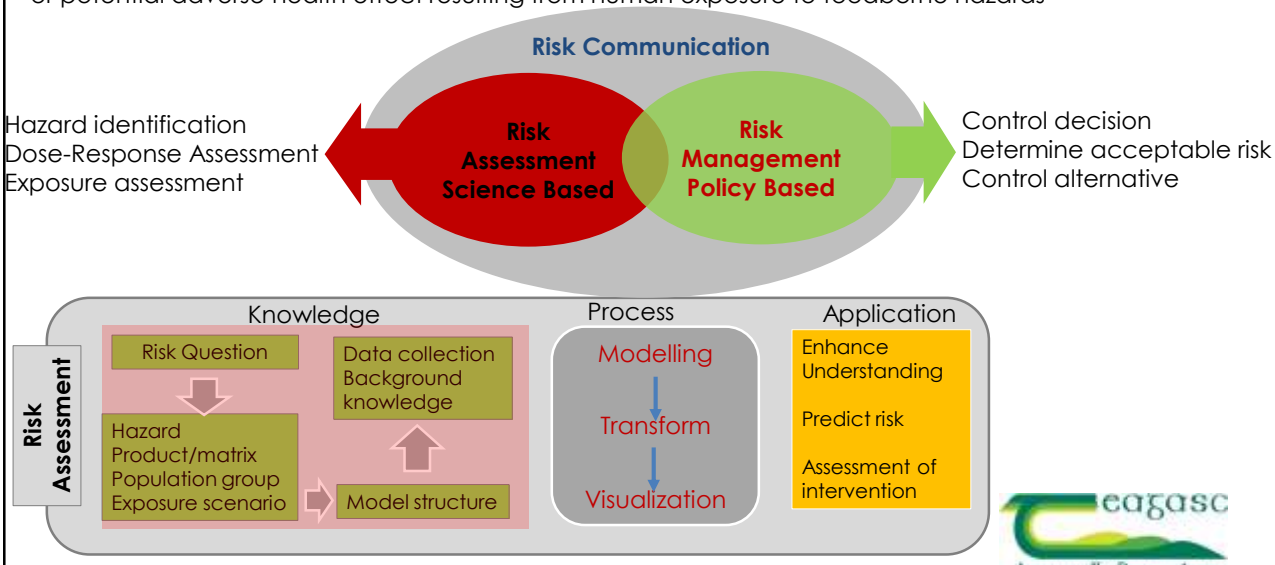
Causes of AMR in Food Chain



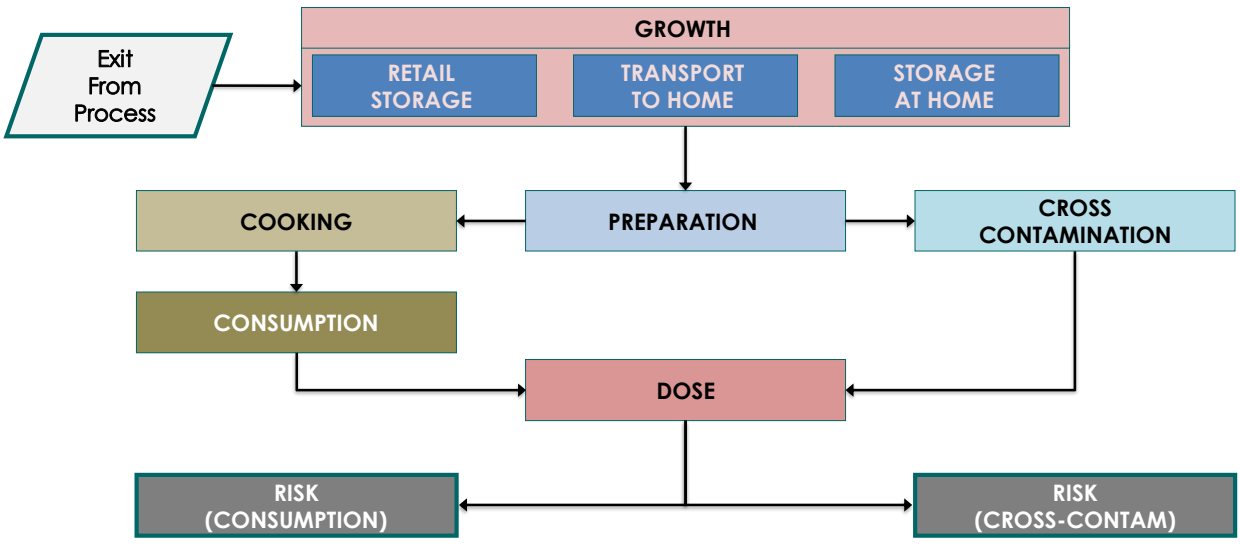
Oniciuc el al (2019), Current Opinion in Food Science, 30:21–26

Risk assessment of novel technologies

RISK ASSESSMENT is a process to scientifically evaluate the probability of occurrence and severity of known or potential adverse health effect resulting from human exposure to foodborne hazards



Exposure assessment *Salmonella* spp in Chicken



Risk assessment of novel technologies

What are the hazards | What can go wrong | What are the potential consequences | How likely is to happen

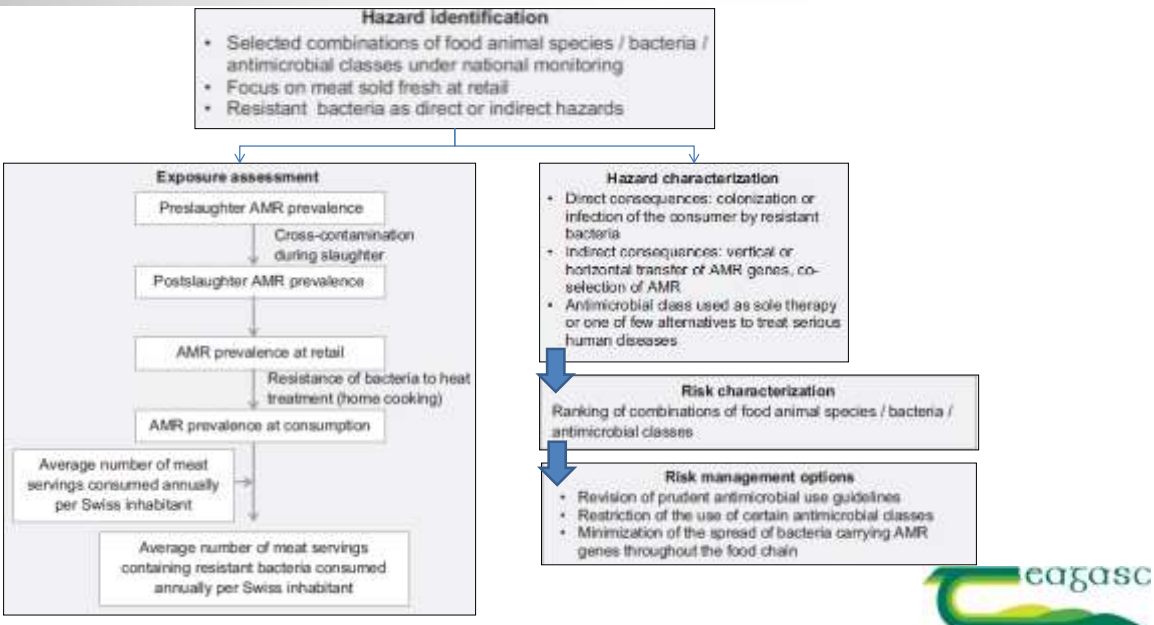
Key Elements of Microbial Risk Assessment

Hazard Identification
Exposure Assessment
Hazard Characterization (Dose-Response Relation + Severity Assessment)
Risk Characterization

FAO/WHO Microbial Risk Assessments
Listeria monocytogenes – ready-to-eat foods
Salmonella in broilers
Salmonella Enteritidis in eggs
Campylobacter in broilers
Vibrio parahaemolyticus in fish and shellfish
Enterohemorrhagic Escherichia coli in ground beef and produce

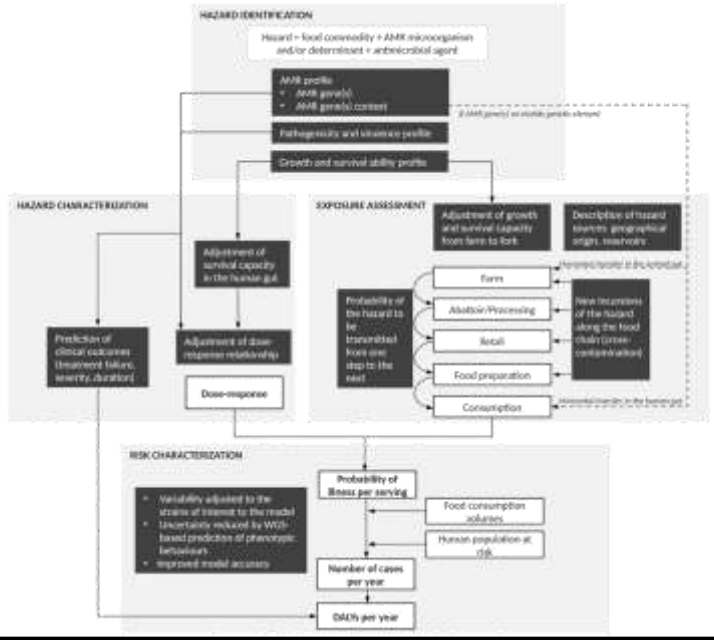
- **Frequency of contamination of food**
- **Number of microorganism when contaminated**
- **Growth before consumption**
- **Frequency of consumption**
- **Amount food consumed**
- **N of microorganisms consumed with a serving**

Overview of the risk assessment framework



Collineau et al (2018) *Risk Analysis, Vol. 38, No. 5, 2018*

Overview of the risk assessment framework



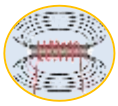
Evidence of cross-resistance between biocides and clinically relevant antibiotics

Microbial species	Biocides used	Antibiotics to which resistance was developed
E. coli	Triclosan	Levofloxacin, amoxicillin, tetracycline and chloramphenicol
Pseudomonas spp.	benzalkonium chloride, Didecyldimonium chloride and sodium hypochlorite	Colistin, ceftazidime, amikacin, meropenem, gentamicin, piperacillin-tazobactam, ciprofloxacin, Polymyxin B, tetracycline, ciprofloxacin
Bacillus spp., Enterococcus spp. and Staphylococcus spp.	Cetrimide, chlorhexidine, benzalkonium chloride, hexadecylpyridinium chloride	Ampicillin, sulfamethoxazole, cefotaxime, Ceftazidime and cefotaxime, among others
Klebsiella pneumoniae	Chlorhexidine	Colistin
E. coli, C. coli, S. enterica, L. monocytogenes	Didecyl dimethyl ammonium chloride	Ampicillin, cefotaxime, ceftazidime, chloramphenicol and ciprofloxacin
C. jejuni	Trisodium phosphate, sodium hypochlorite, acetic acid and a commercial alkaline biocide which contains sodium lauryl ether sulfate, linear alkyl benzene sulfonic acid, sodium salt, propylene glycol monomethyl ether, and dipropylene glycol n-propyl ether	Kanamycin, streptomycin
S. enterica serovar Typhimurium	A mixture of aldehydes and QAC; a QAC; an oxidative compound; a halogenated tertiary amine compound, A blend of oxidizing compounds; a QAC containing formaldehyde and glutaraldehyde; a biocide composed of organic acids and surfactants	Nalidixic acid, ciprofloxacin, chloramphenicol, tetracycline, Nalidixic acid, chloramphenicol, tetracycline, ciprofloxacin, Ciprofloxacin, chloramphenicol, tetracycline, and ampicillin

Novel food processing technologies

Novel Food Processing Technologies


Thermal


Electro-magnetic


Biotechnological


Mechanical

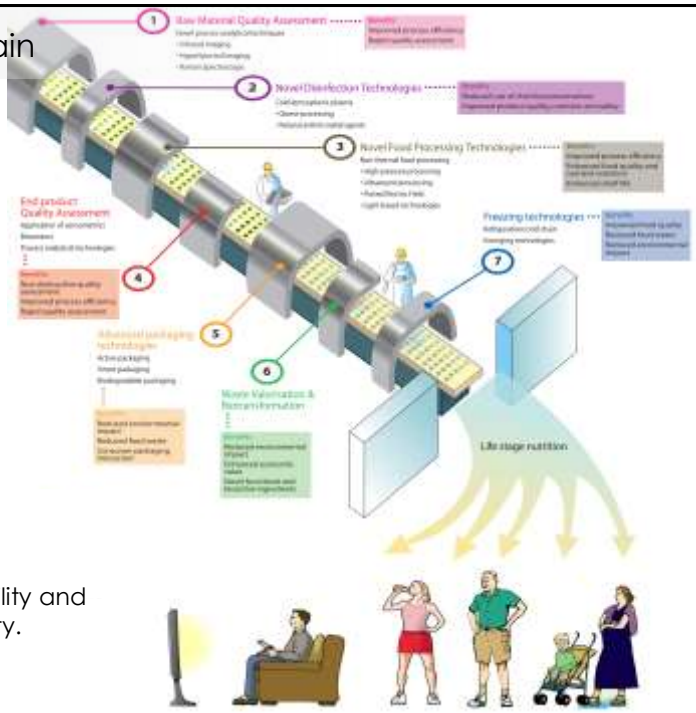
Combination

Smart Solutions

- Ensure food safety
- Improved shelf life
- Nutrient retention
- Environmental friendly
- Process efficiency

Novel technologies across food chain

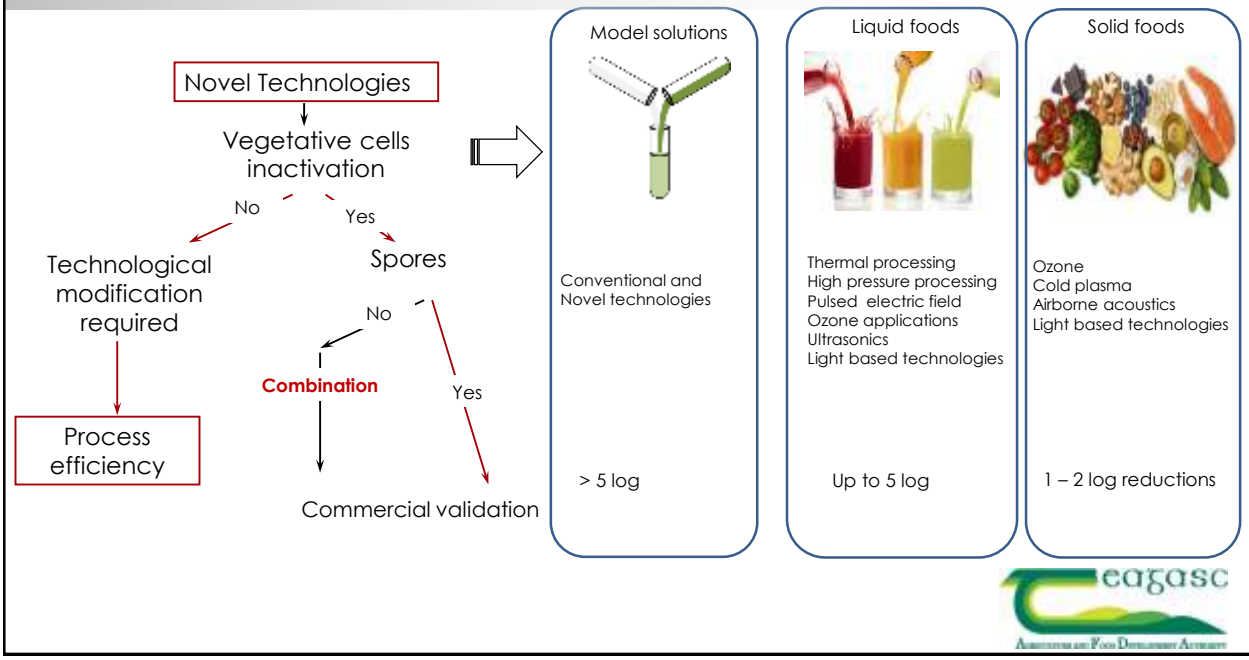
- ✓ Improved food quality
- ✓ Reduced energy and water consumption (clean and green solutions to key challenges faced by the food industry)
- ✓ Employ new interventions for developing new food products underpinning key health, nutrition and wellness challenges



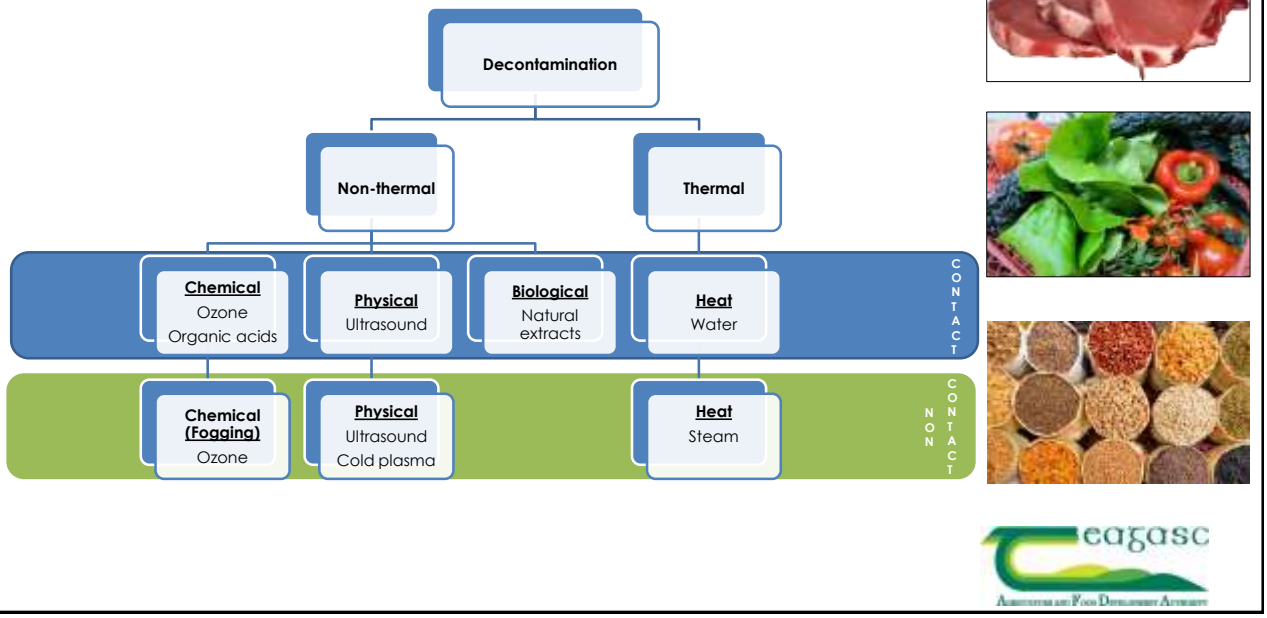
Mechanism of AMR

- ✓ Enzymatic degradation of antibiotics,
- ✓ Antibiotic target modification,
- ✓ Changing the bacterial cell wall permeability and
- ✓ Alternative pathways to escape the activity.

Selection of technologies



Surface Decontamination Technologies

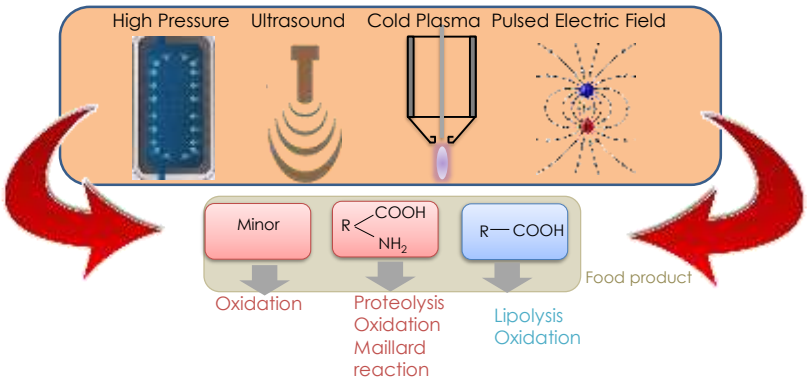


Microbial aspects of novel technologies

Key mechanisms		PEF	US	Cold plasma	UV light	Ozone	Thermal
	Pressure	Electroporation	Sonoporation		Oxidation		Heating
Vegetative cells							
Damages to cell membrane	+++	+++	+++	+++	+++	++	+++
Inactivation of key enzymes modulating growth of cells	++	++	++	+	+		+++
Oxidative damages to cell membrane constituents (peptidoglycan layers)	++	++	+	+++	+++	+++	+++
Damage to DNA/Nucleic acid	–	–	–	++	+++	++	+++
Spores							
Damage to spore coat	++	++	+++	++	++	++	+++
Chemical modification in spore core and cortex	+	++	+	++	+	+	+++

+++: key mechanism of action
++: some synergistic effects
+: based on limited scientific information
–: Not reported

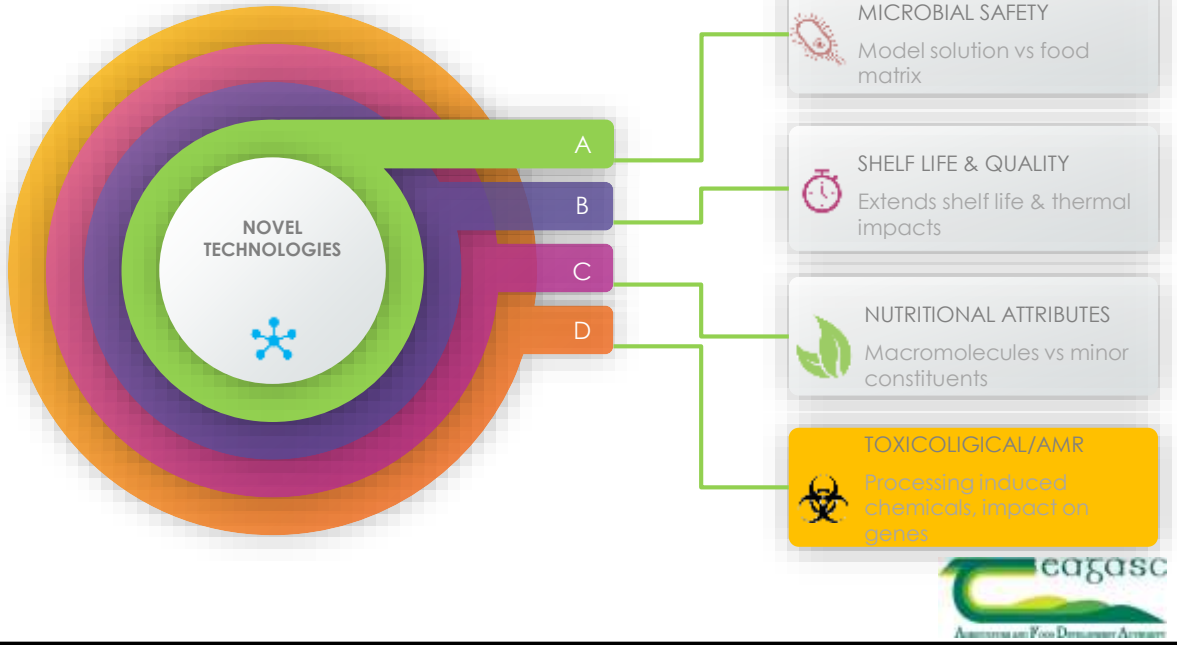
Chemicals aspects of novel technologies



Effects	High Pressure	Pulse Electric Field	Ultrasound	Cold Plasma
Protein				
• Oxidation	+	-	+	+++
• Denaturation	+++	++	+++	++
• Aggregation	++	++	++	++
• Proteolysis	+	-	+	+
Lipids				
• Oxidation	+	+	++	+++
• Lipolysis	++	+	–	++

+++: Significant effect
++: Moderate effect
+: Low effect
-: No reported

Known and unknowns of novel technologies



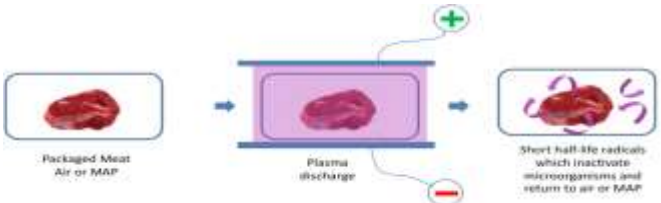
Cold Plasma Technology

- Plasma (an energetic ionised gas) is widely used for industrial material processing.
- A novel nonthermal approach for reducing the microbial populations on surfaces

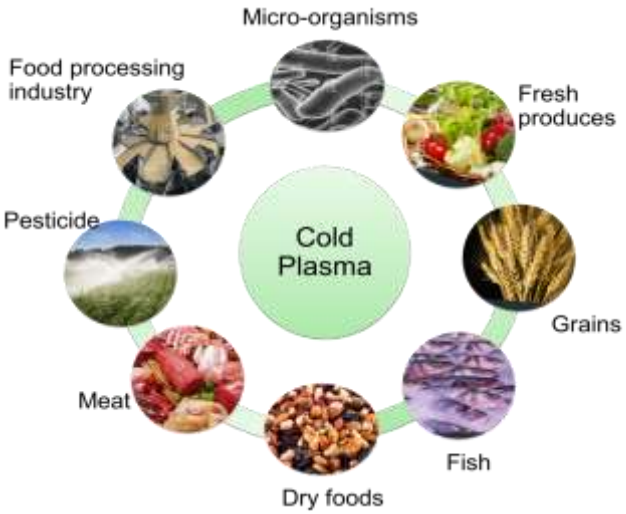
Thermal, electric, magnetic field, radio or microwave frequencies

Reactive oxygen species (O, O^3)
Reactive nitrogen species (N_2, NO^-)

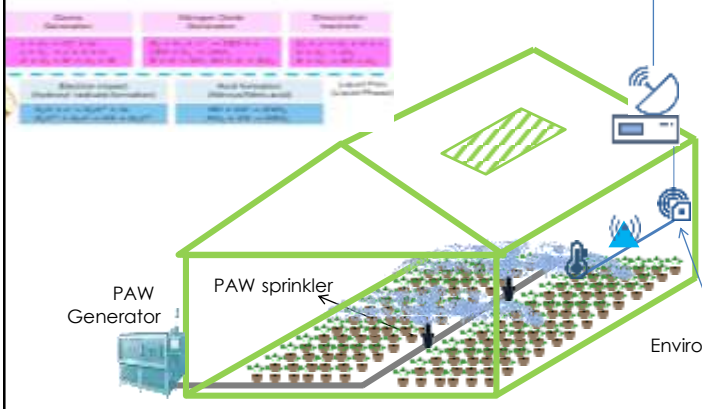
Neutral gas → e^- e^- Atoms becomes ions e^- → Plasma → *Sample*

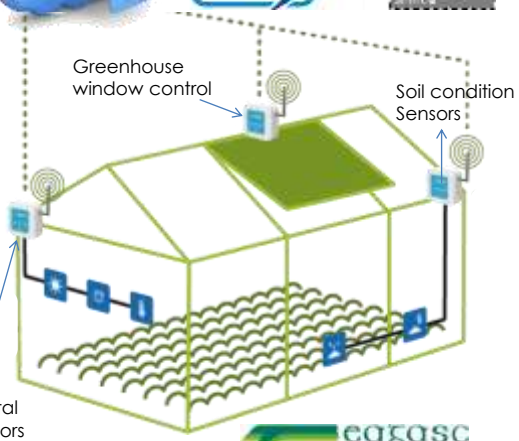


Application of Cold Plasma Technologies

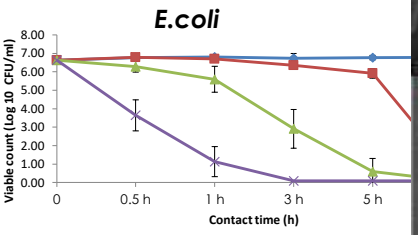


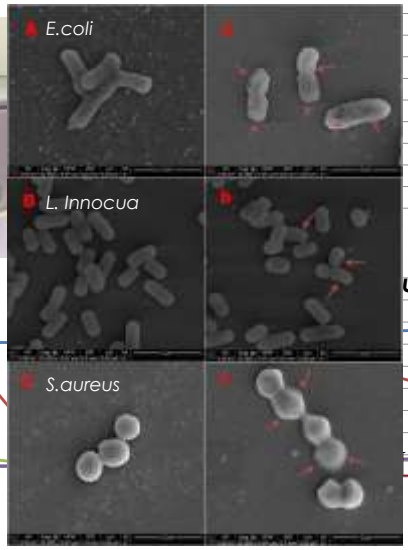
Crop production

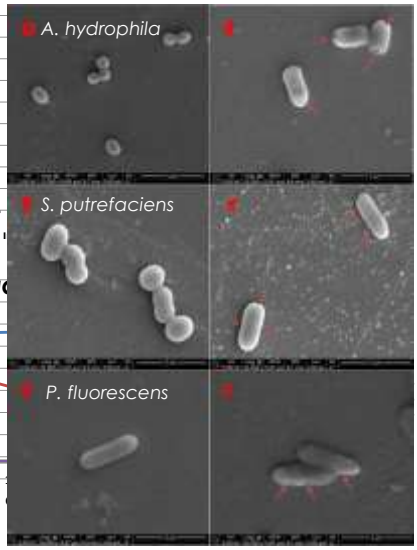




Effect of PAW on microbial load

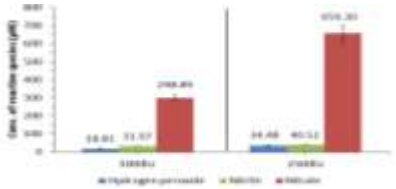






Effect of Plasma on biofilms

Direct treatment of bacterial biofilms

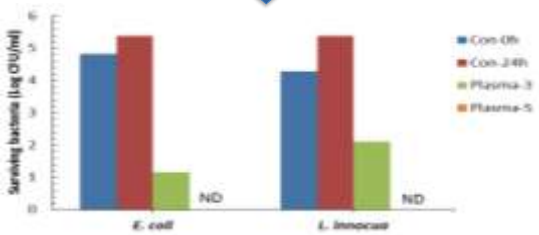


Reactive species generated

Control

3min ACP treated

Confocal analysis: green (live cells), red (dead cells)



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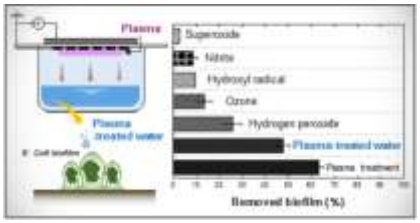
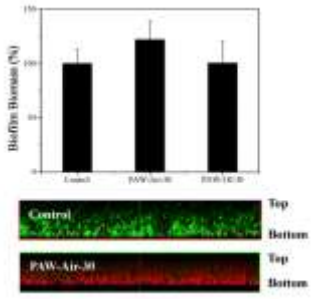
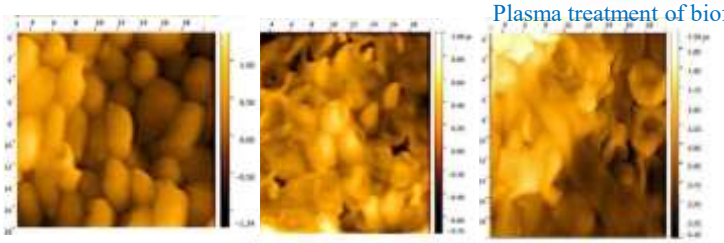


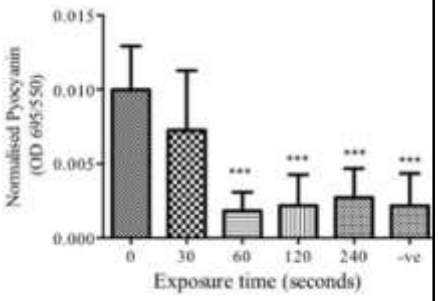


Plasma treatment of biofilms



Untreated biofilm 120s 300s

Atomic force microscopic images of plasma treated biofilms

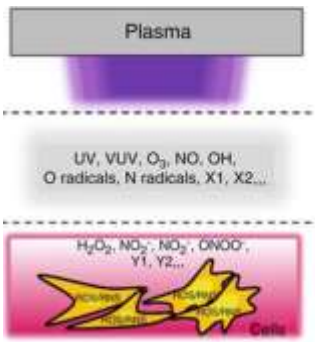


Effect of plasma on QS regulated virulence factors

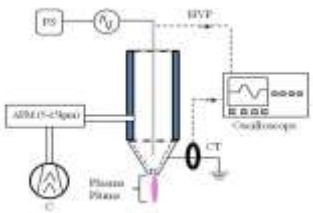
Flynn et al., 2016 Scientific reports.

Handorf et al., 2018 Appl. Environ. Microbiol

Mechanisms of action - Plasma

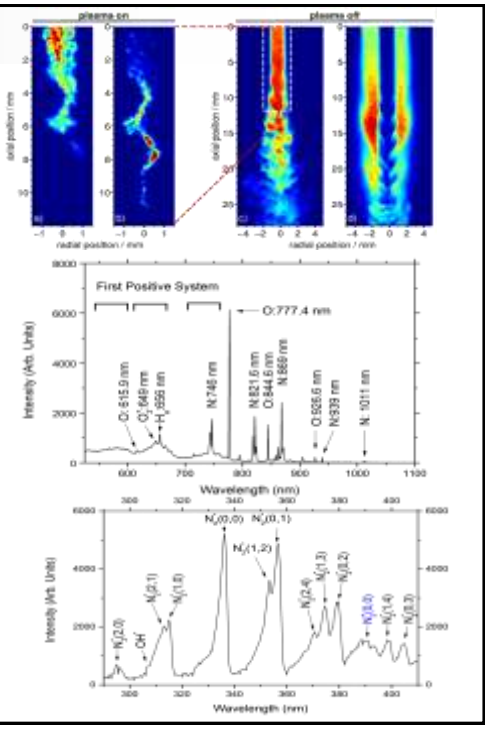


Reactive oxygen species (O, O^3)
Reactive nitrogen species (N_2, NO^-)



Gas phase

e + H_2	H + H +e	e+O_2	O + O+ e
	H_2^+ +e +e		$O(^1D)$ + O +e
e +NO_2	O^- + NO		$O_2(a^1\Delta)$ + e
e+NO_2+M	NO_2^-+M		O_2^++ e+ e
e+NO_3+M	NO_3^-+M	e+N_2	$N(^2D)$ + N+ e
e + H_2O	H_2O^++e +e		N_2 ($A\ ^3\Sigma$) + e
	OH^++ H + e +e		N_2($B\ ^3\Pi$) + e
	H^++ OH +e +e		N_2^++e + e
	O^++H_2 + e + e		
	H_2^++O +e +e		
	OH + H +e		
	H_2 + $O(^1D)$ +e		
	O^- +OH		
	OH-+H		



Risk assessment – associated with Cold Plasma Technology

Potential risk factors using cold plasma technology:

- electrical charge system
- thermal damage
- formation of UV radiation on the product surface during treatment

Although no evidence on undesired side effects of a plasma treatment has yet been presented, research currently are in process to detect

- Short term → Cytotoxic effects
- Long term → Mutagenic effects

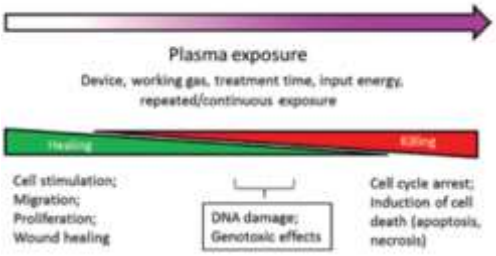
Electric currents, UV radiations displays certain impact on cell performance, however, so far no adverse effects have been attributed

No mutagenic action of the kinpen plasma in mammalian cell line

Complex bio-fluids showed increased mutation frequency over time

Treatment reduced the toxicity of the food sector effluents, however, Cyto-eco-toxicity varied depending on treatment parameters.

Endotoxin responsible for pathogenicity in *bacteria* is reduced with cold plasma and non-toxic to Galleria mellonella



Optimum treatment parameters should be set to minimise risk factors

The mix of these parameters has to be adapted individually for each application

Further investigations regarding the nature and safety of plasma-treated food products

Conclusions

- Available risk assessment framework for QMRA should modify to focus on resistant micro-organisms
- Scientific information available on technologies is mainly associated with food safety/quality
- Limited studies are available on AMR/WGS of novel technologies
- Approval of Novel technologies for food application for food safety purposes is not yet approved in many countries.
- Majority of novel technologies are for niche application
- Replacement of antibiotics and chemical preservative with natural alternative would provide solution to AMR.