Le scienze e tecnologie alimentari nella bioeconomia

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA
CAMPUS DI CESENA

SISTAL
SOCIETA' ITALIANA DI SCIENZE E TECNOLOGIE ALIMENTARI

Marco Dalla Rosa

ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA

DISTAL / CIRI AGROALIMENTARE

CAMPUS DI SCIENZE DEGLI ALIMENTI - CESENA

La SISTAL- Società Italiana di Scienze e Tecnologie Alimentari - è organo di espressione dei Docenti Universitari impegnati nell'insegnamento e nella ricerca nel settore specifico - AGR/15.

La Società si propone di contribuire al progresso della scienza e delle sue applicazioni nel campo della conservazione, della trasformazione, della commercializzazione, della gestione e controllo della qualità e sicurezza degli alimenti, anche nei riguardi della percezione di questi temi da parte dei mezzi di informazione e dei cittadini e dell'insegnamento ai vari livelli.

Presidente in carica Prof.ssa Ernestina Casiraghi

I NUMERI DELL'INDUSTRIA ALIMENTARE ITALIANA (2017)

- **137 miliardi** di fatturato
- **58.000 imprese** (di cui 6.850 con oltre 9 addetti)
- **385.000** addetti
- **32,1 miliardi** di export
- **22,1 miliardi** di import

5,6 miliardi per l'Emilia Romagna!
4800 imprese attive nel settore

Elaborazioni Centro Studi Federalimentare su dati ISTAT

FOCUS SULL'OCCUPAZIONE (2017)

- Nel **2017**, **385.000 persone impiegate:**
  - 43% nella produzione
  - 22% nel controllo e nella gestione della sicurezza e della qualità
  - 19% nel marketing
  - 9% in logistica e stoccaggio
  - 7% in finanza e amministrazione.

- Ha mantenuto **inalterati i livelli occupazionali durante la crisi.**
  - Marginale diminuzione di 20.000 unità dal 2007 (da 405.000 a **385.000 lavoratori** dipendenti).
  - Nel 2015 si stima che siano entrati nel settore circa **1.800 laureati**, di cui oltre l'80% provenienti da Università italiane.

Fonte: Federalimentare e Unioncamere

INDUSTRIA ALIMENTARE TRA TRADIZIONE E INNOVAZIONE
LA SFIDA DELL'INNOVAZIONE

10 MLD DI € (8% DEL FATTURATO) INVESTITI OGNI ANNO DALL'INDUSTRIA ALIMENTARE IN RICERCA E INNOVAZIONE:

- **l'1,8% in R&S** formale ed informale di prodotti e processi innovativi
- oltre **il 4%** in nuovi impianti, automazione, ICT e logistica
- il **2% del fatturato** in analisi e controllo di qualità e sicurezza

I TREND DI SVILUPPO:

- Convenience
- Naturalità/freschezza dei prodotti
- Texture
- Ricettazione e sue riformulazioni
- Porzionamento
- Valenze nutrizionali e salutistiche
- Occasione e luogo di consumo
- Attenzione a bisogni religiosi/etnici/etici
- Attenzione all'ambiente e alla sostenibilità

Fonte: Federalimentare 2017

FST & Bioeconomy CHALLENGES

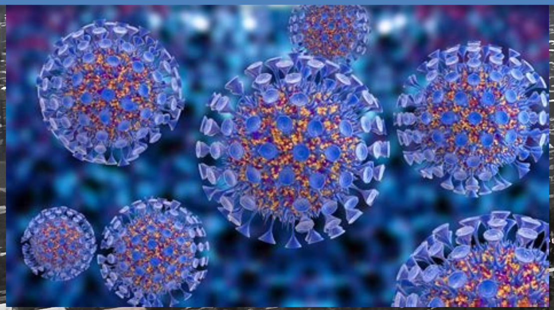
UN World Population Prospects

Population 9,6 Billions @ 2050

Urbanization 66% @ 2050 (54% on 2014)

Increment of middle class 4,8 Bill. @ 2030 (1,8 Bill. on 2009)

Climate changes

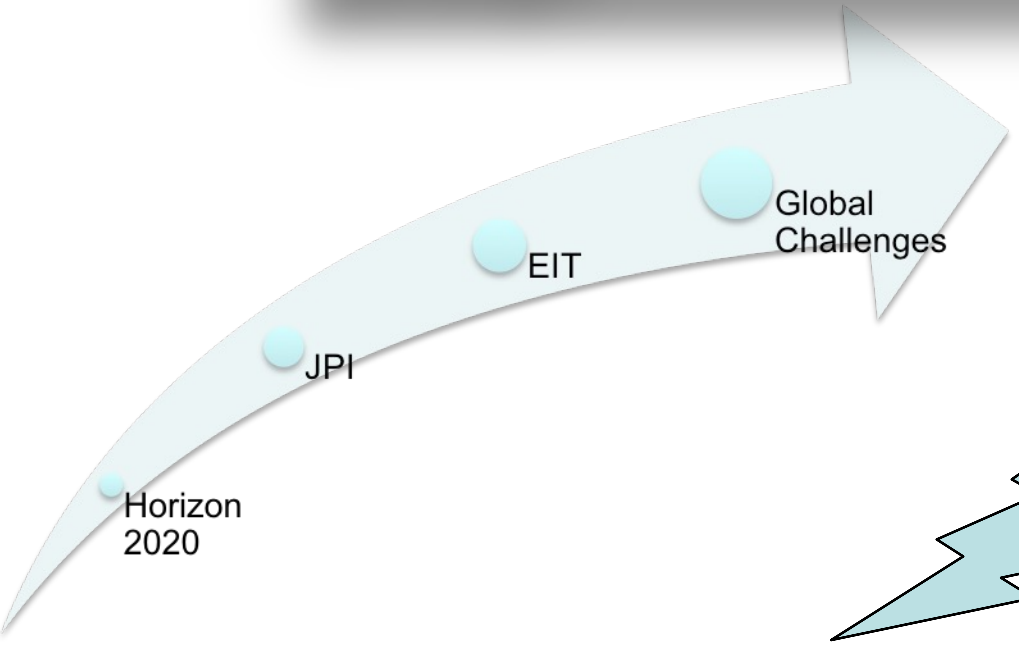


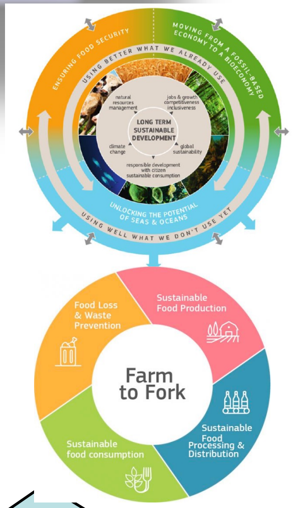
COVID-19 Pandemic

Global Food Crisis

Toward 2030: Beyond the borders

Changing Food Technology paradigm





Keyword: Innovation

Society &

Consumer’s

well being

sustainability

crossing

nutritional,

clinical,

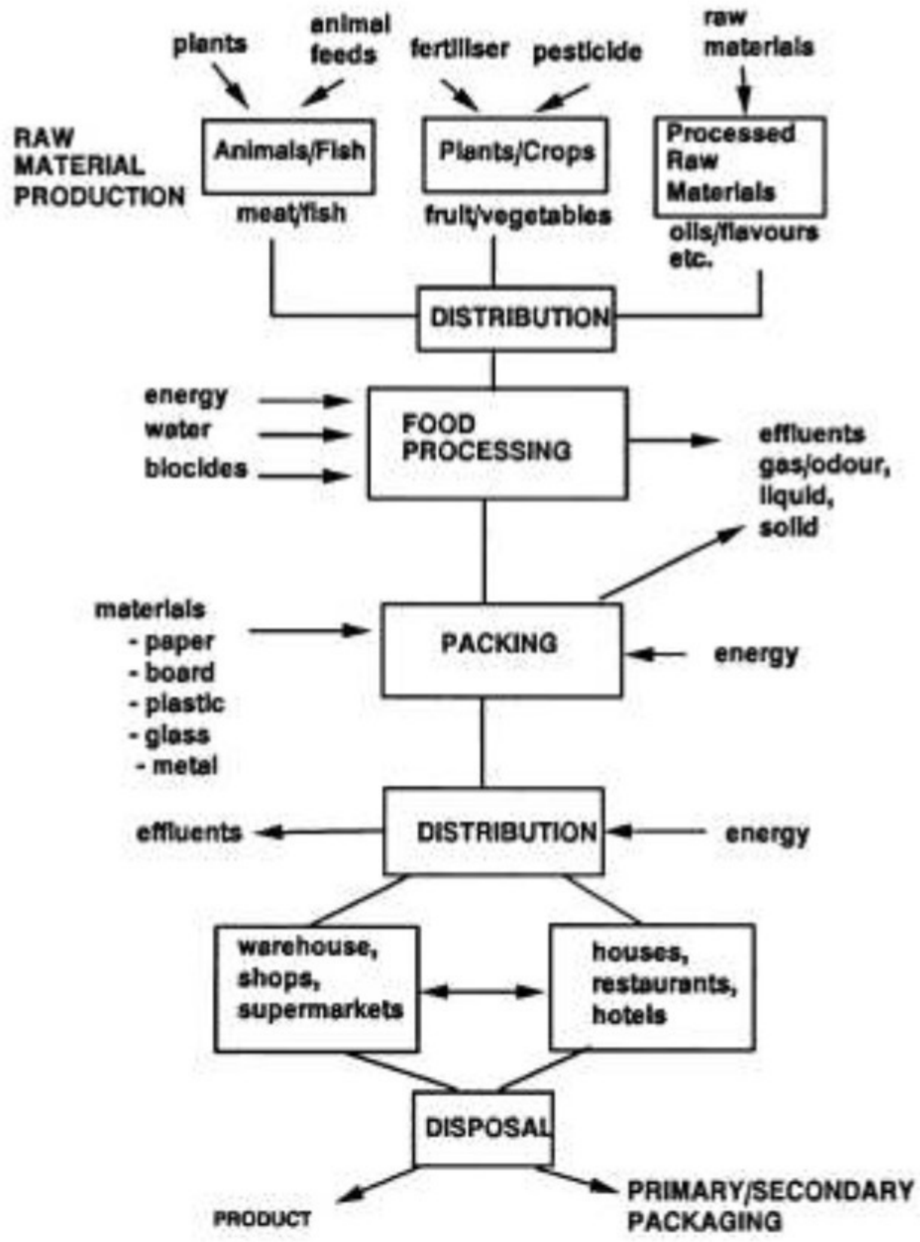
psicological,

social,

cultural

Environments

STA competenza in tutte le fasi della filiere alimentari



dalle fasi di post-raccolta

a tutte le fasi formulazione, processo, packaging e distribuzione

fino alla gestione e valorizzazione di sottoprodotti e scarti

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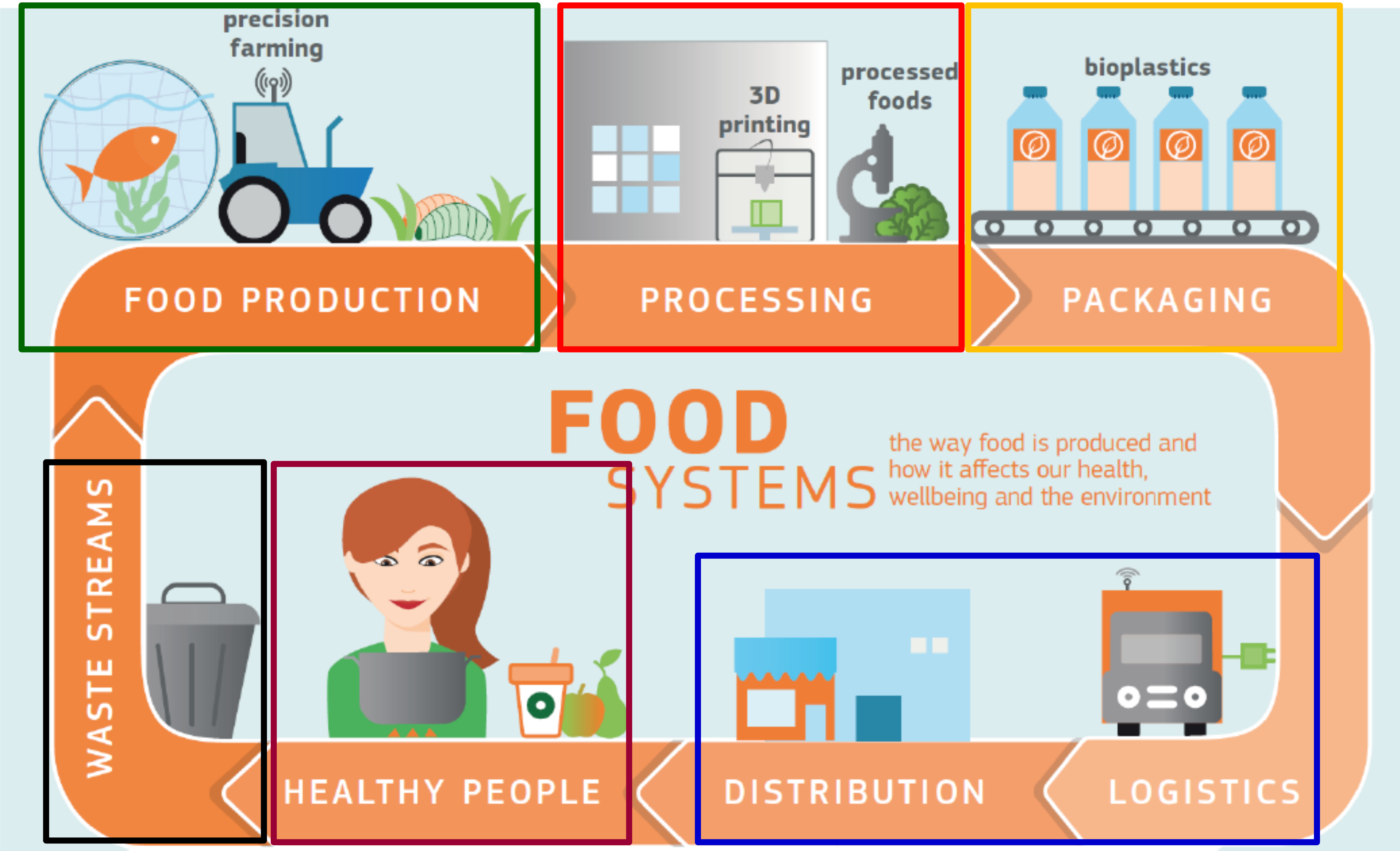
Main R&I priorities for the agrifood sector



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Principi dell'Economia Circolare per favorire la sostenibilità delle produzioni.

- Uso efficiente di materie prime come acqua ed energia,
- prevenzione degli sprechi alimentari
- gestione delle eccedenze alimentari,
- progettazione del packaging,
- riciclo e valorizzazione dei sottoprodotti

Garanzia di genuinità e tracciabilità dei prodotti trasformati legati a territori e tipicità

314: EU DOP, IGP STG,

48 In Emilia-Romagna

406 Vini DOP

119 Vini IGP

Sfide e obiettivi

- innovazioni di prodotto e di processo attuate anche con approcci biotecnologici,
- tecnologie termiche a prestazioni migliorate
- tecnologie non termiche (pressioni di omogeneizzazione, HPP, campi elettrici pulsati, plasma freddo atmosferico, impregnazione sottovuoto, ultrasuoni;
- sistemi per aumento della efficienza dei flussi nei processi,
- analisi LCA

AZIONI

- Studio delle interazioni e degli effetti del processo e della materia prima sulla struttura degli alimenti.
- Sviluppo di processi di trasformazione innovativi.
- Studio di packaging innovativi ed estensione della shelf life.
- Produzione di alimenti innovativi e salutistici.
- Nanotecnologie per la realizzazione di rivestimenti innovativi.
- Riduzione e valorizzazione dei sottoprodotti.

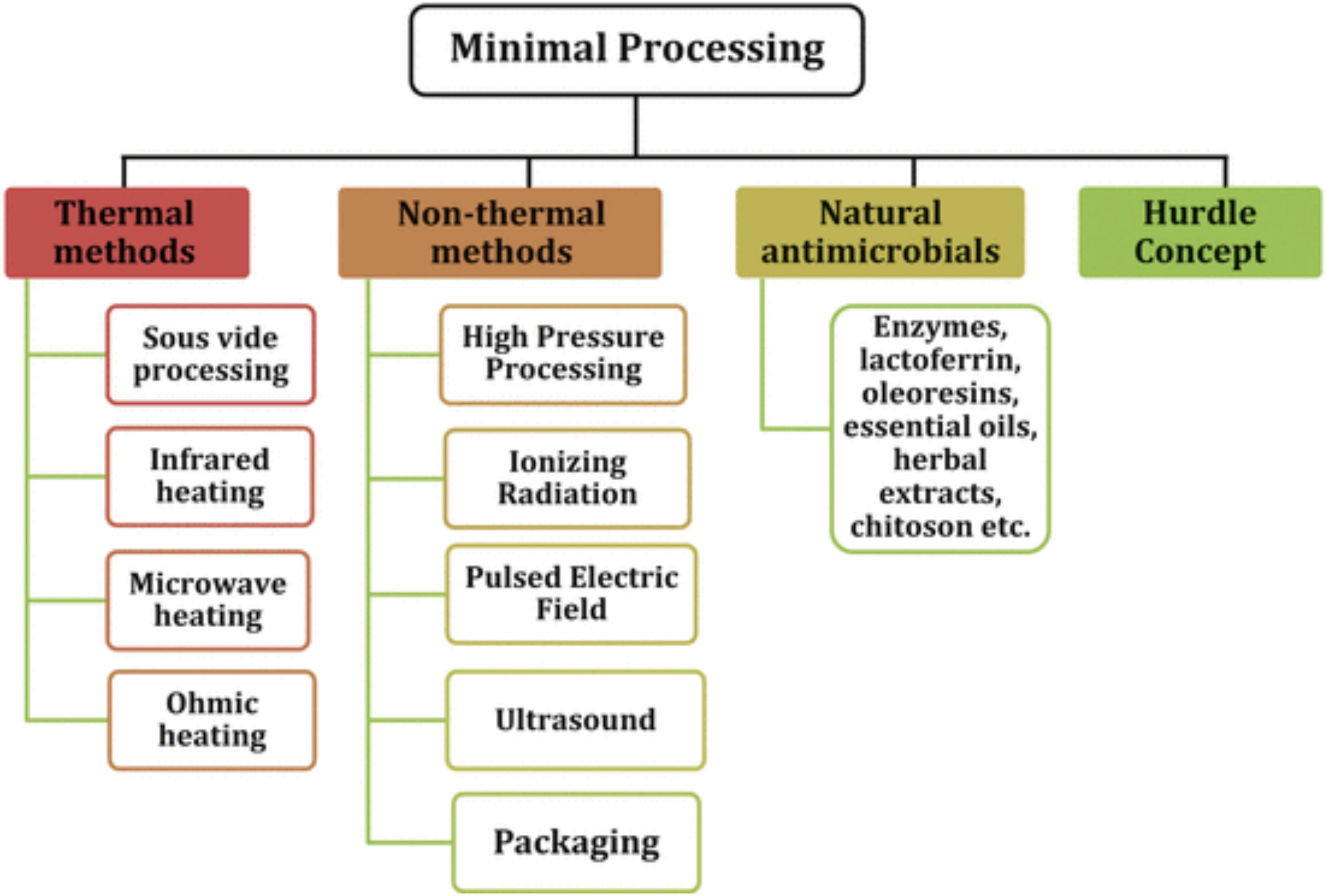
Efficientamento dei processi

- crucial factor in food processing,,
- need to monitoring energy, product and water fluxes in processing plants.
- Cold chain optimization by IoT digitalized platforms
- to avoid over-processing (sterilization, dehydration, blanching, freezing, cooling, etc.)
- introducing higher efficiency thermal processes (MW, RF, Ohmic heating)
- to better understand quality behavior kinetics during processing and storage through intelligent sensors
- appropriate use of Big Data sets to **modeling kinetics in real conditions** (systematic engineering approach)

Smart Technologies to reduce energy demand/ environmental impacts

Emerging technologies

Emerging technologies for:
safe - healthy - minimally processed foods



Emerging technologies

Classification on non-thermal technologies based on engineering aspects

Electrotechnologies and electromagnetic technologies

pulsed electric fields (PEF)
cold plasma technologies (CPT: e.g. atmospheric cold plasma, CAP; PAW)
magnetic fields (MF)
electrohydrodinamic processing (EHD)
ionizing radiation (IOR; e.g. electron bean (EB) processing

Pressure-based technologies

vacuum impregnation (VI)
high hydrostatic pressure (HHP/HPP)
hydrodinamic pressure processing (high pressure homogenization, HPH)
supercritical fluid processing

Mechanical technologies

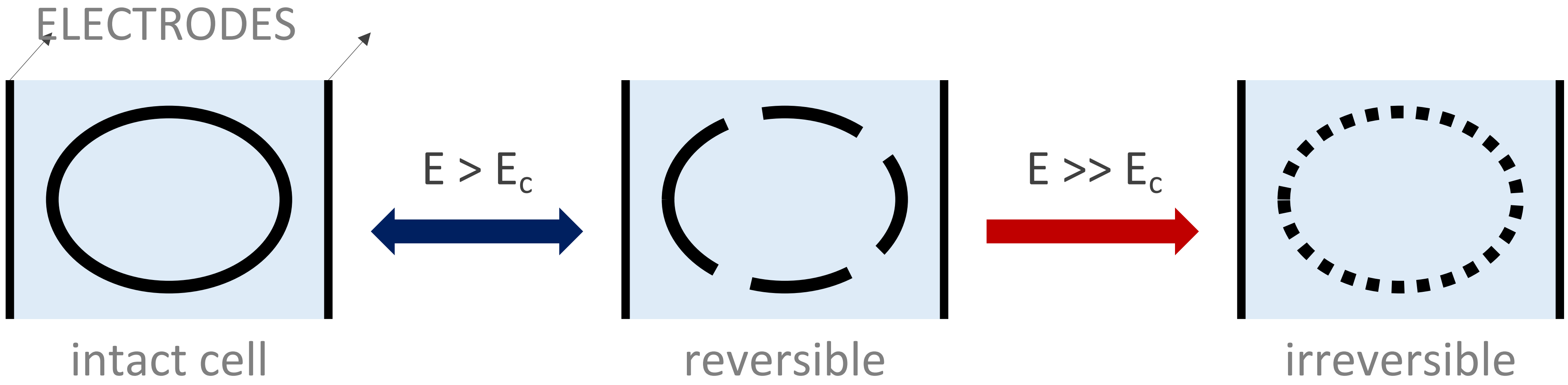
ultrasonication (US)
hydrodinamic cavitation
shock waves

Others

(Jambrak A.R. Ed., 2022)

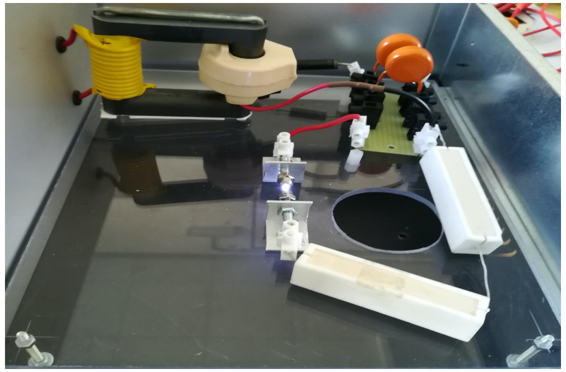
UV light
pulsed light
membrane technologies (microfiltration, membrane separation etc.)
modified atmosphere

PULSED ELECTRIC FIELDS (PEF)
Increased efficiency of matter transfers



ELECTROPORATION

PEF prototype:
microbic inactivation/ electroporation

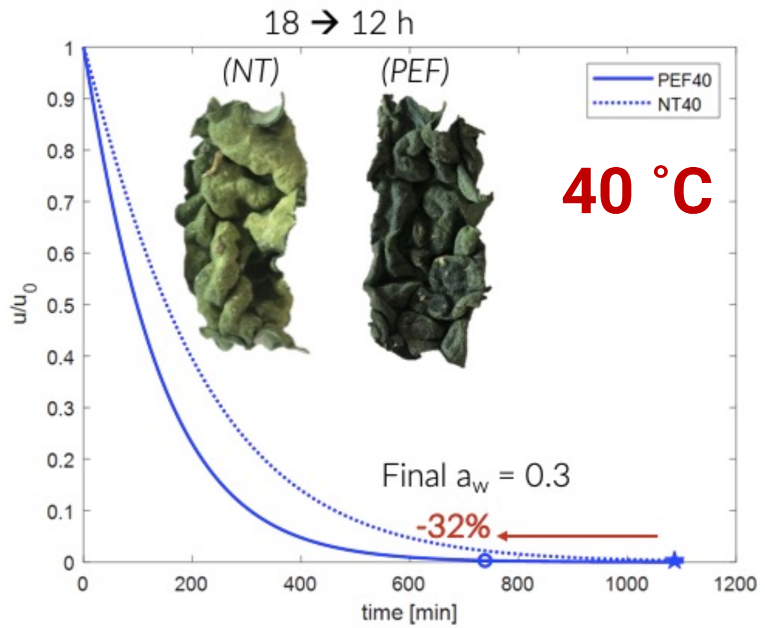


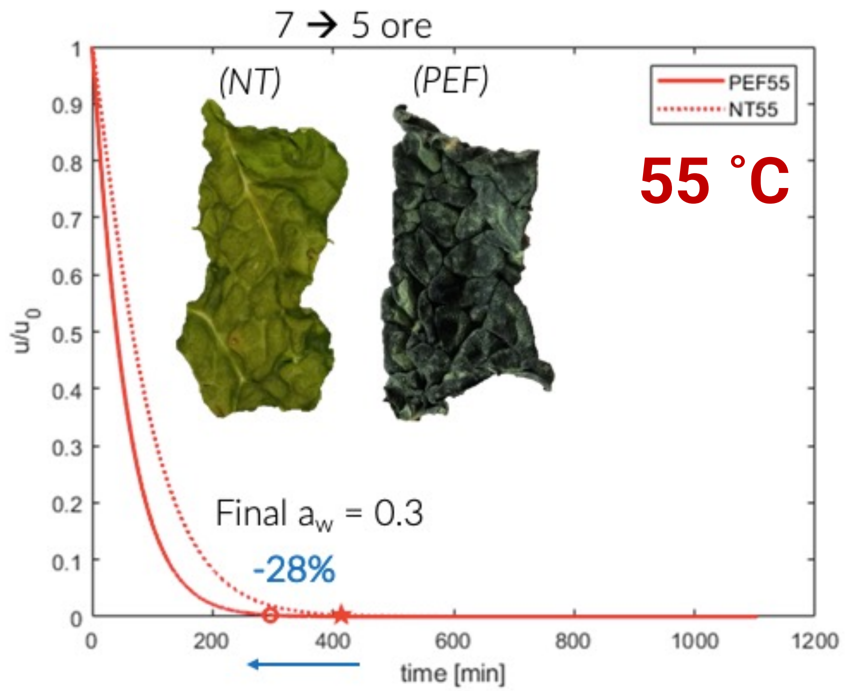
UP-SCALING

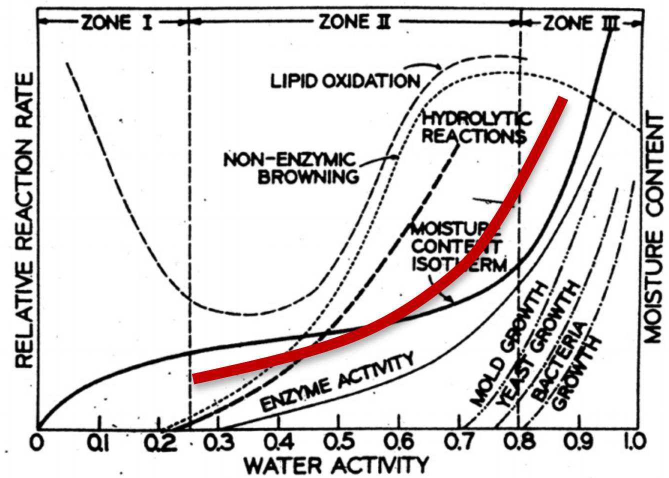
Industrial scale

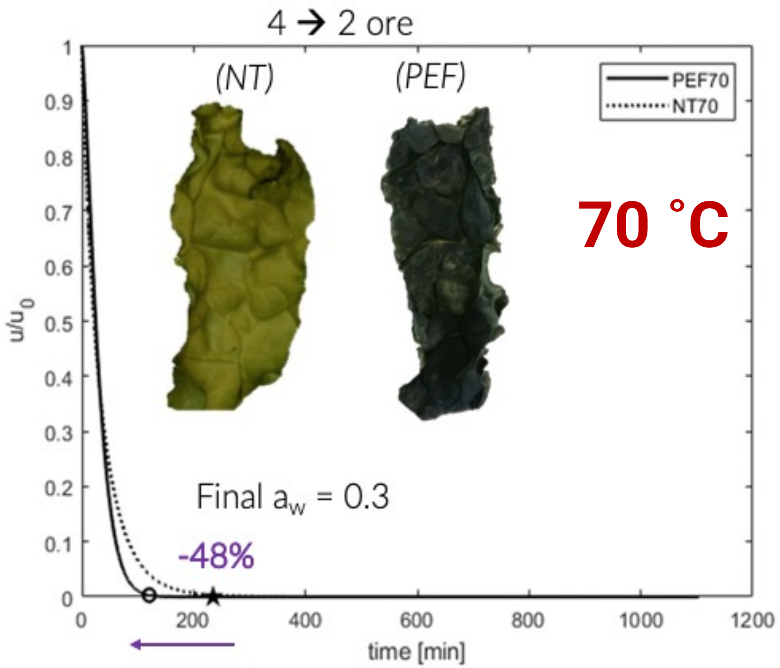
IGBT - based

Hot Air Drying









Miglioramento caratteristiche qualitative e cromatiche

Tempi e costi di esercizio ridotti

Maggiore produttività

FRESCO NT PEF

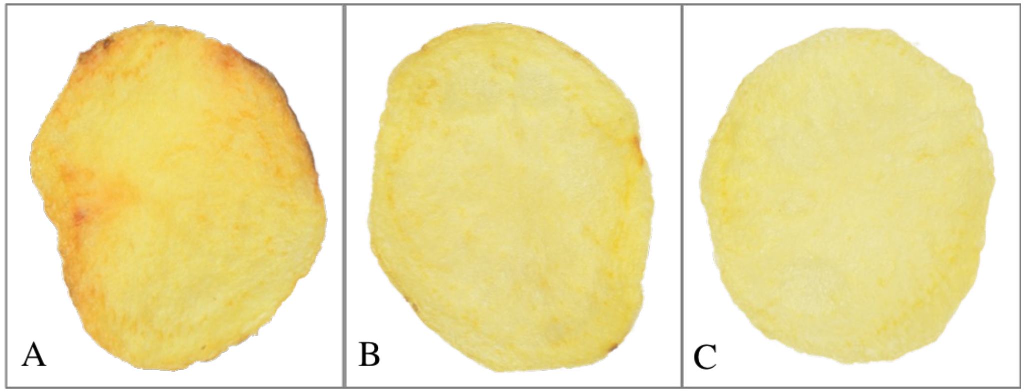
Source:
F. D'Elia (Master thesis). **Effetto dei campi elettrici pulsati sull'essiccazione di prodotti vegetali**, 2019.

Potato Chips

	Acrylamide (ppb) Means ± standard deviations
UNTREATED	1958 ± 64
BLANCHING	1617 ± 147
PEF	1355 ± 101

✓ **~30%** Reduction of acrylamide in samples pretreated with **PEF**

✓ **~17%** Reduction of acrylamide in samples pretreated with **Blanching**



A – Control

B – Blanching

C - PEF

Genovese J, Tappi S, Luo W, Tylewicz U, Marzocchi S, Marziali S, Romani S, Ragni L, Rocculi P.
Important factors to consider for acrylamide mitigation in potato crisps using pulsed electric fields. *Innovative Food Science & Emerging Technologies*. 55:18-26, 2019.

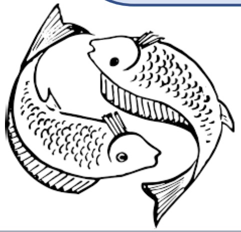
STA & BIOECONOMIA

Gas plasma treatment (UNIBO)

Gas mixture
Temperature
Relative humidity

Characterization of plasma emission (UNIBO)

Title:
Optimization of cold plasma treatment for the stabilization of food products



Treatment of:
Seafood (mollusks and fish), fresh, MP and dehydrated fruit and vegetables, dried products (UNIBO)

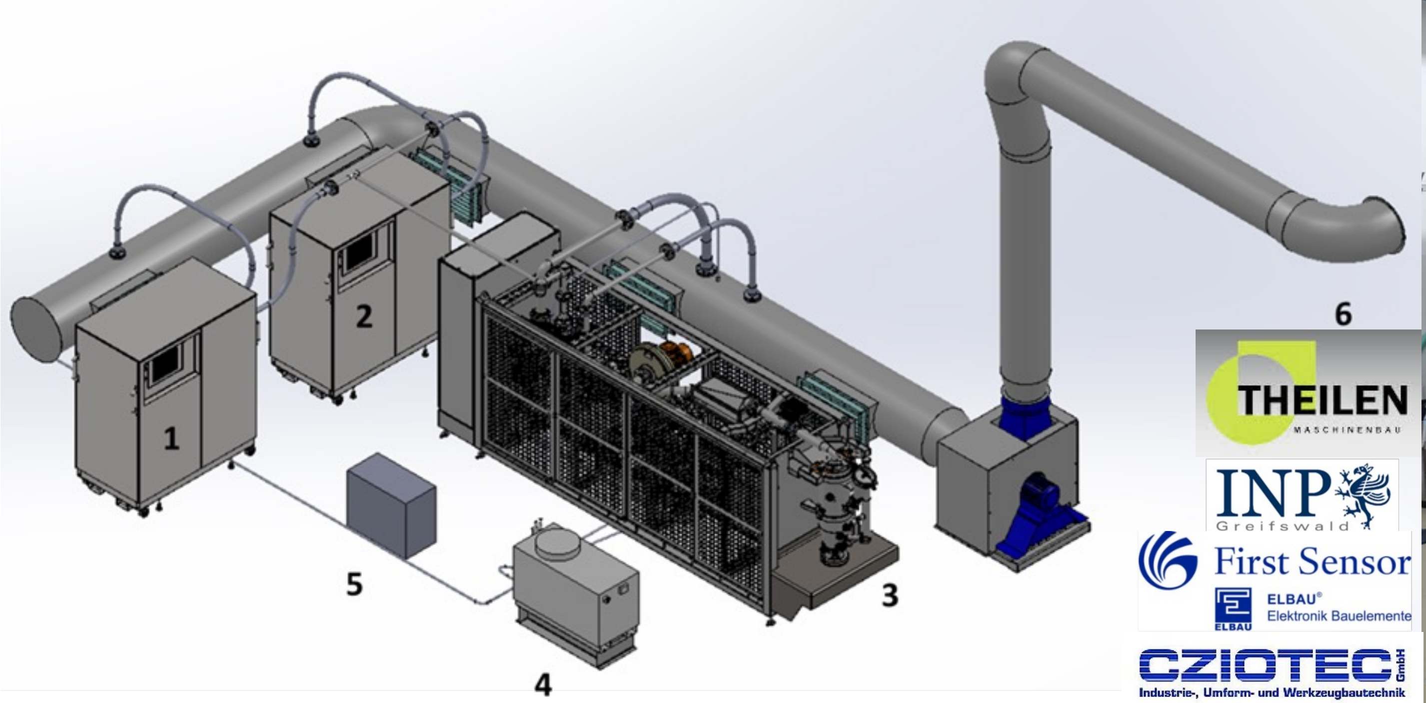
Safety
Microbial inactivation (UNIBO)
Virus inactivation (ISS)
Mycotoxin inactivation (UNITE)
Biogenic amines (UNICAM)

Quality
Rheology (UNIPR)
Colour (UNIPR)
Texture (UNIPR)
Enzymes activity (UNITE)

Nutritional profile
Bioactive compounds content (UNICAM)
Lipid oxidation (UNIVPM)
Antioxidant properties in vitro/ex vivo (UNIPR)

Metabolism of tissues
Heat production (UNIBO)
Respiration rate (UNIBO)
Cell viability (UNIBO)

Plasma dryer in pilot scale



Combination of PLexc² units with a fluidized bed dryer. 1, 2. ADU (auxiliary decontamination unit); 3. Fluidized bed dryer; 4. Steam generator; 5. Control unit; 6. Outlet exhaust gas. (Theilen Maschinenbau GmbH, unpublished 2018).

- Combination of drying and plasma can reduce the treatment time and microbial load
- Maximal load of 3-4 kg product

STA & BIOECONOMIA

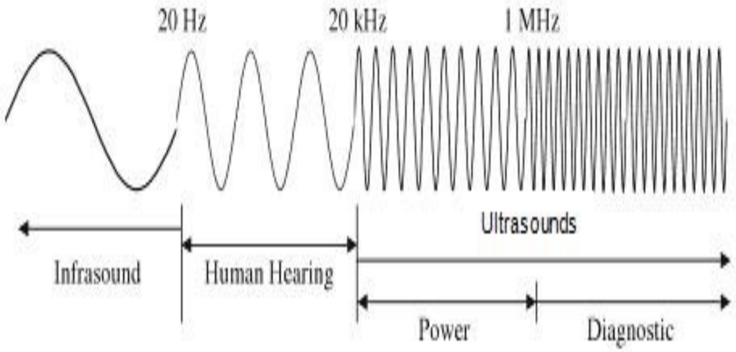
Use of Ultrasounds (US)

- US at high intensity (power >1 W cm^{-2} and low frequency <0,1 MHz

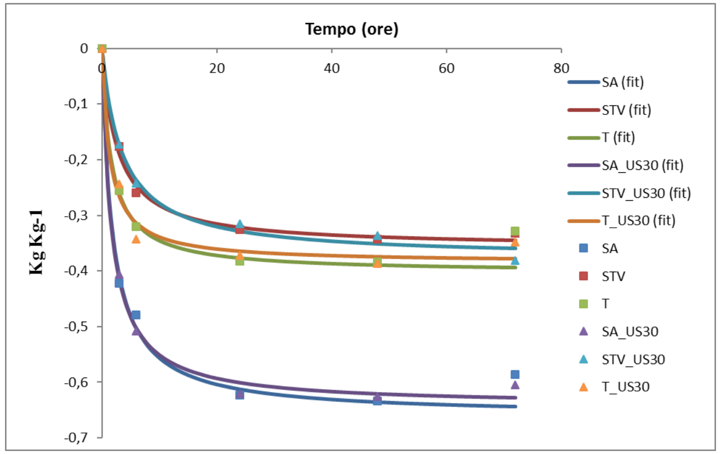
✓ Inactivate microorganisms and enzymes

✓ Improve mass transfer

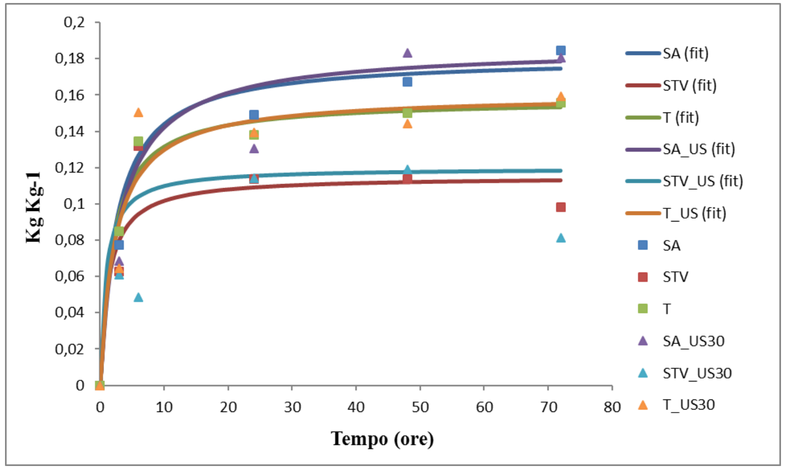
✓ Improve heat transfer



Water loss



Solid gain



INNOFRUVE

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Increasing supply chain sustainability:

Study of shelf life of cookies formulated with more environmentally sustainable raw materials

- Formation of 3- MPCD
- Incessant deforestation
- Declining biodiversity

Progressive disuse of PALM OIL

B0

PALM OIL 100%

B4

HIGH OLEIC SUNFLOWER OIL 100%

B5

87.5% COCONUT OIL AND HIGH OLEIC SUNFLOWER OIL12.5%

SHELF LIFE (giorni)

- ✓ All samples show peroxide values well below the imposed legal limit (20 meqO2/kg) for all storage times.
- ✓ The cookie formulated with palm (B0) showed significantly-more hexanal content than the other two samples for all storage times.
- ✓ Higher resistance to forced oxidation (**OXItest**) than the palm cookie (B0) but all three formulations show oxidative stability during storage.

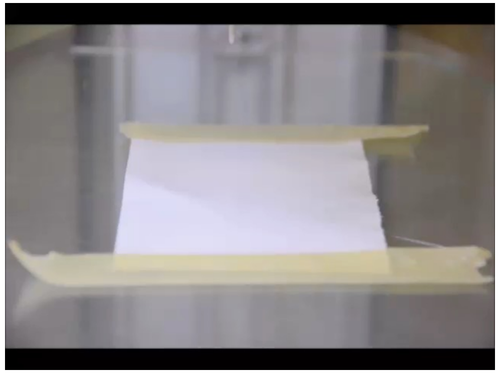
Promising lipid alternatives for formulating sweet baked goods

Digital innovation in in food processing

Non destructive analysis during processing

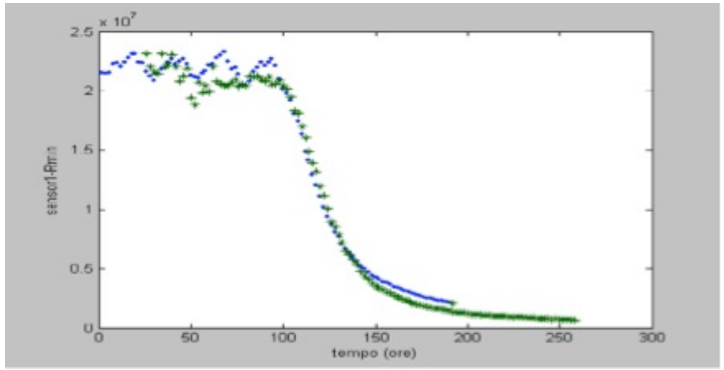
Visual assessment

3D Printing



By courtesy of Severini, 2018

Robotics



e-nose response

wearable data acquisition system

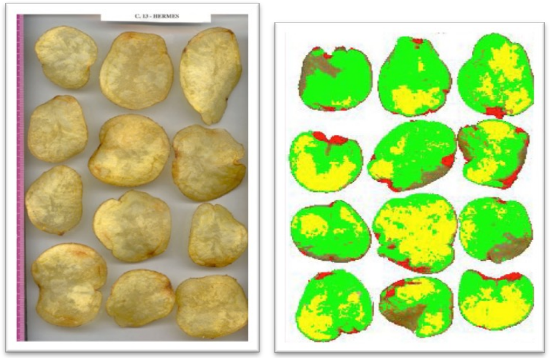


image analysis

Data acquisition in food processing

Consumer definition of PAN

Quality & Safety Objective Factors

M_1 = f1 (M_o , Operation conditions)
M_1 = f2 (Quality & Safety Objective factors)

- M; Raw Material & Product properties
- MC = $M_2 - M_1$; Changes in the values of M throughout the process.

Engineering approach (Fito, 2006)

ETP F4L, FQ&M

Modeling to preview frozen vegetables shelf-life

Journal of Agricultural Engineering 2021; volume LII:1199

pagepress

Simple and efficient approach for shelf-life test on frozen spinach and parsley

Eleonora Iaccheri,[1] Chiara Cevoli,[1,2] Santina Romani,[1,2] Marco Dalla Rosa,[1,2] Giovanni Molari,[2] Angelo Fabbri[1,2]

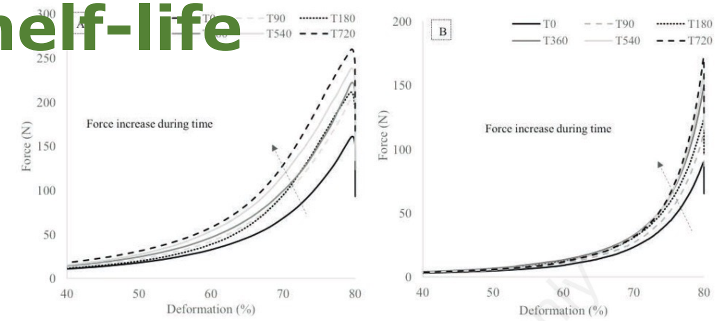


Figure 2. Mean force-distance curves of spinach (A) and parsley (B) samples stored at –26°C as a function of time (0-720 days).

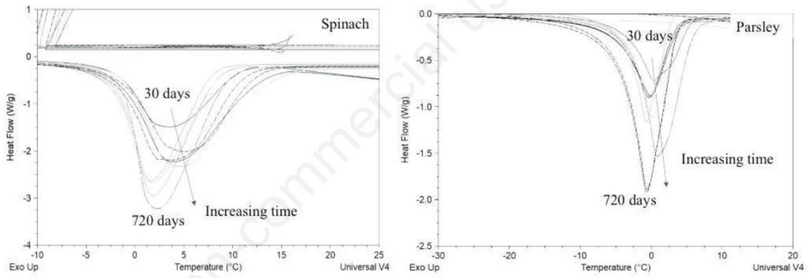


Figure 3. Endothermic peak of ice melting of spinach and parsley samples during storage time, referred to spinach and parsley samples stored at –26°C.

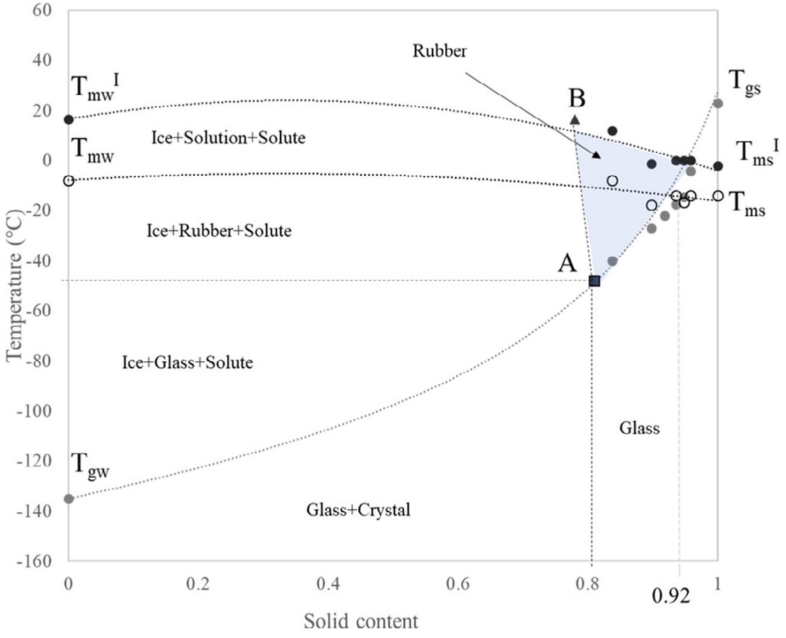
ORIGINAL ARTICLE

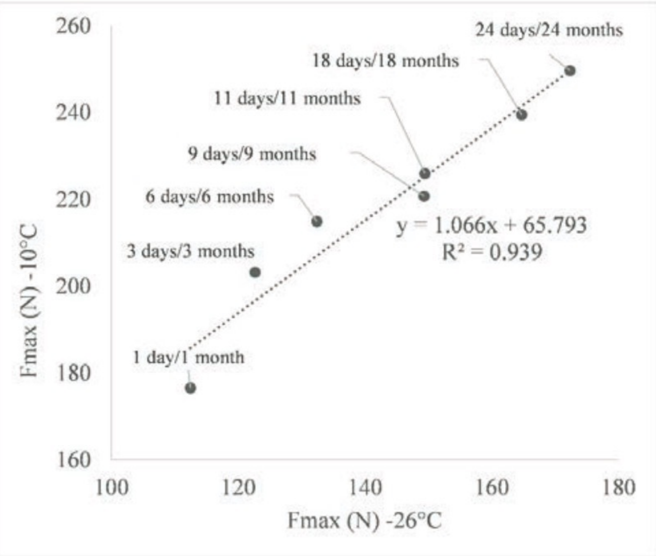
Journal of Food Process Engineering

WILEY

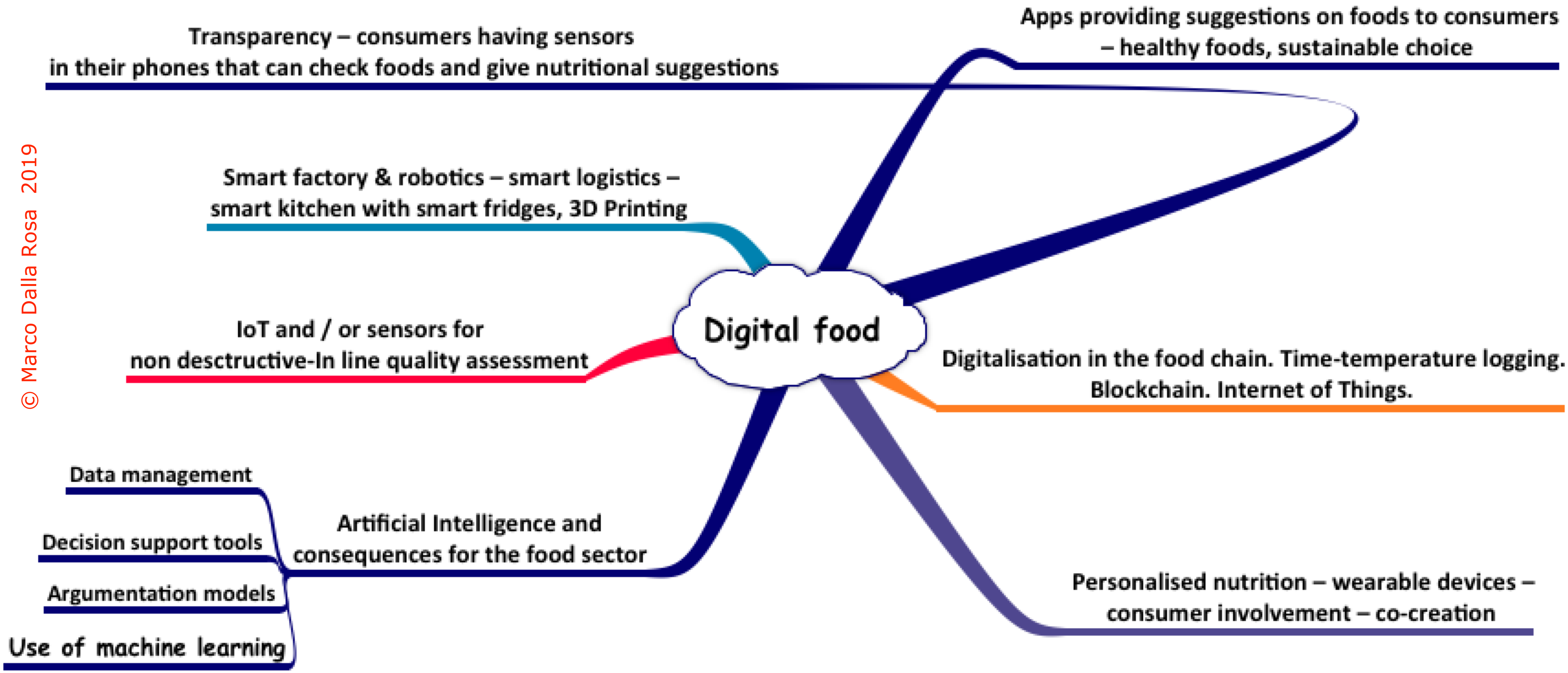
Thermophysical properties of frozen parsley: A state diagram representation

Eleonora Iaccheri[1] | Ch





Digitalization in the Food Industry

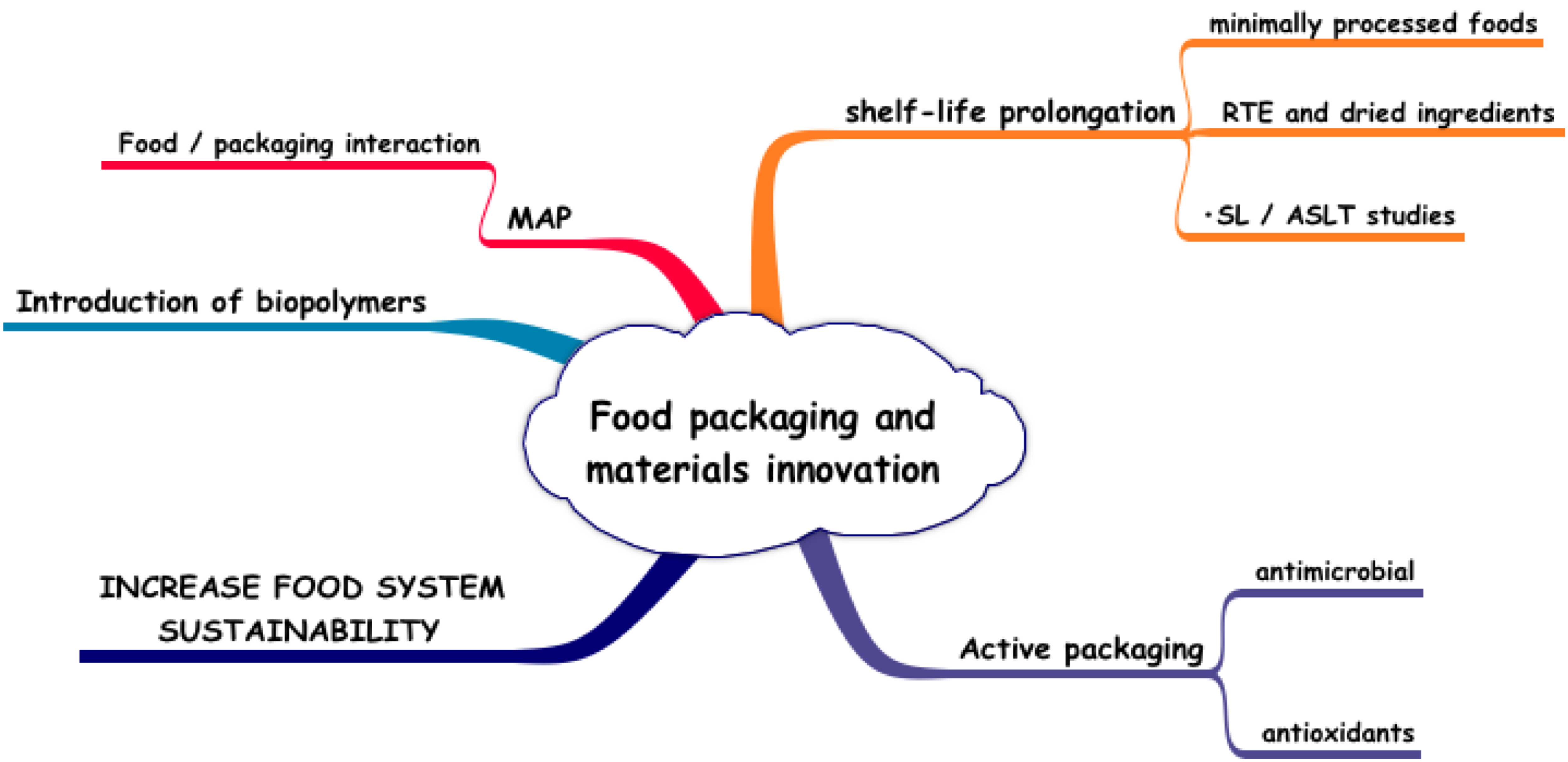


Sustainable Packaging

Sviluppo di processi di trasformazione innovativi: Packaging

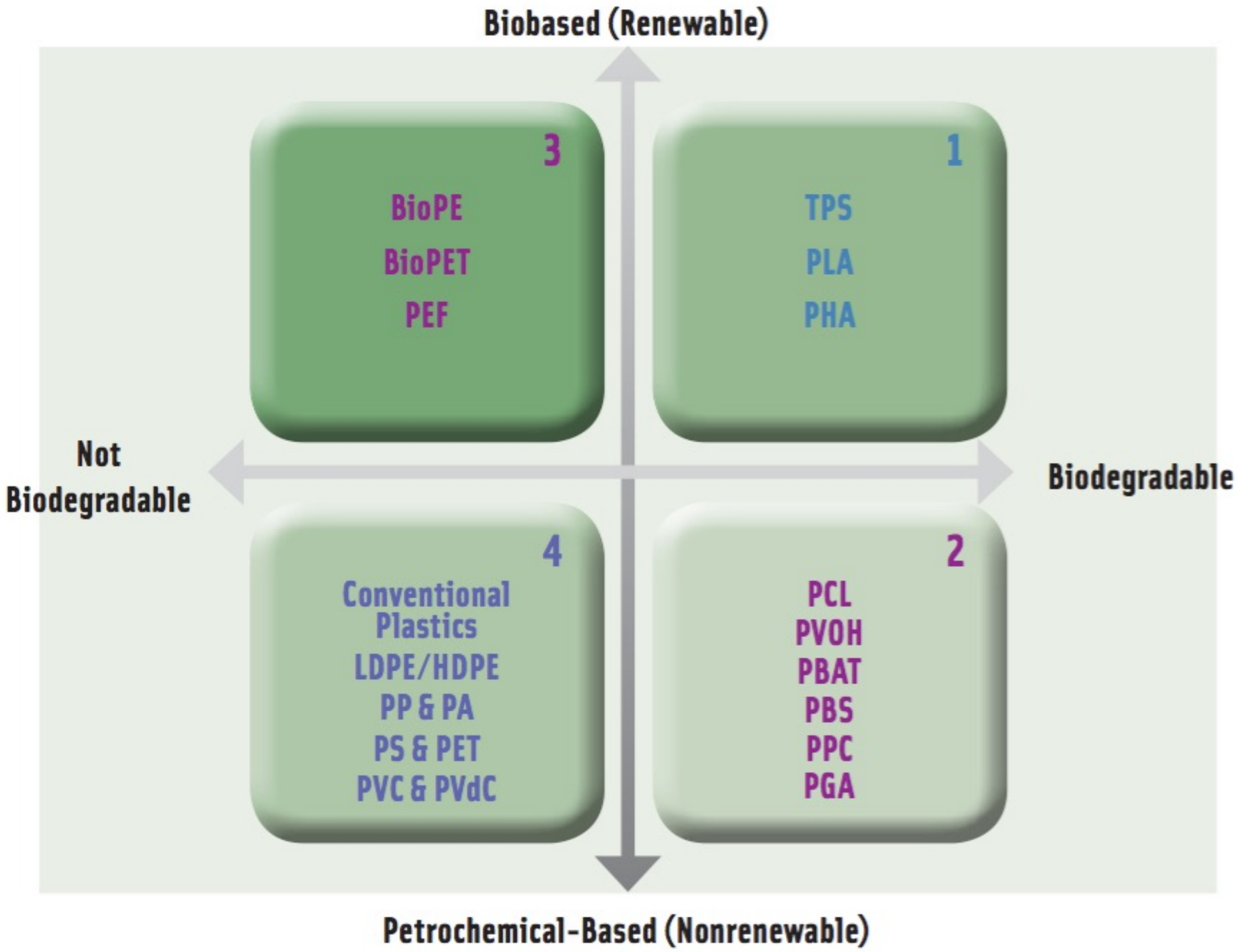
- il miglioramento di shelf-life, proprietà sensoriali e nutrizionali, e la loro stabilità nel tempo, mantenendo un livello di sicurezza;
- la riprogettazione dei sistemi di packaging in un'ottica di fine vita (ad es., packaging monomateriale più facilmente riciclabile) e verifica delle prestazioni per applicazioni specifiche;
- le prestazioni tecnologiche di packaging compostabili (ad es. barriera al vapore acqueo e all'ossigeno);
- l'adozione di sistemi di active packaging come strategia per bilanciare le performance eventualmente inferiori di nuovi packaging più riciclabili e/o compostabili;
- l'impiego di materiali innovativi, fibre e biomateriali biodegradabili ed attivabili, sostanze utilizzabili per rivestire gli alimenti (edible coating) dovranno essere testati e validati relativamente ai problemi dei materiali e oggetti a contatto con gli alimenti (MOCA) per giungere alla dichiarazione di conformità MOCA e alla certificazione degli impianti di processo e confezionamento;
- lo sviluppo di software dedicati per il controllo dei processi di trasformazione e di confezionamento, la progettazione meccanica avanzata e il disegno igienico, per la riduzione di tempi, costi e impatto ambientale per le fasi di pulizia e sanitizzazione e confezionamento degli impianti e aumentando delle rese di processo.

Programma Nazionale per la Ricerca 2021-2027


Food packaging and materials innovation
shelf-life prolongation
minimally processed foods
RTE and dried ingredients
•SL / ASLT studies
Food / packaging interaction
MAP
Introduction of biopolymers
INCREASE FOOD SYSTEM SUSTAINABILITY
Active packaging
antimicrobial
antioxidants

Biobased and biodegradable Food Packaging Materials

STA & BIOECONOMIA



ROBERTSON, Food Technology, 06.14

Need to find solutions to improve biobased-film performances

Mechanical properties

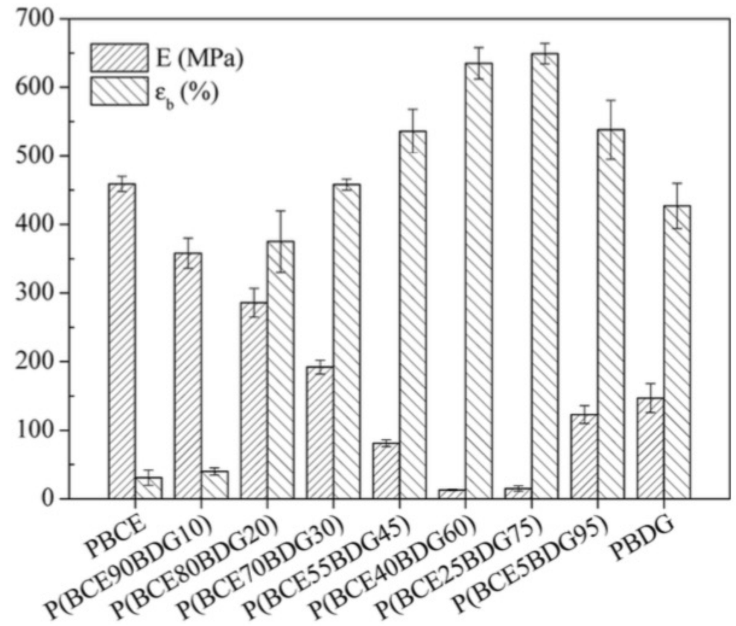


Figure 9. Elastic modulus (*E*) and deformation to break (ε_b) as a function of copolymer composition.

Gas transmission rate

	GTR ($cm^3\ m^{-2}\ d^{-1}\ bar^{-1}$)		Selectivity
	CO_2	O_2	Ratio CO_2/O_2
PBCE			5.66
P(BCE90BDG10)	318.33 ± 2.05	56.20 ± 0.22	6.89
P(BCE80BDG20)	450.00 ± 0.82	65.30 ± 0.08	6.93
P(BCE70BDG30)	404.67 ± 1.25	58.43 ± 0.12	8.67
P(BCE55BDG45)	709.43 ± 4.92	81.80 ± 0.08	8.51
P(BCE40BDG60)	806.00 ± 0.82	94.73 ± 0.17	10.19
P(BCE25BDG75)	1880.33 ± 0.47	184.57 ± 0.42	10.46
P(BCE5BDG95)	1370.33 ± 0.47	131.17 ± 0.46	10.03
PBDG	309.00 ± 0.82	30.8 ± 0.16	12.07
	270.00 ± 0.82	22.37 ± 0.40	2.4
PLA	1201.00 ± 1.73	487.67 ± 2.52	

the copolyesters showed lower permeability, and therefore improved barrier properties, to both CO_2 and O_2 gases with respect to polylactide (PLA).

PLA as reference since is the most extensively used polyester in the production of biodegradable packaging film

Biodegradation *vs.* Recycling

Converting a solid material into a gas via composting or biodegradation should only be a last resort.

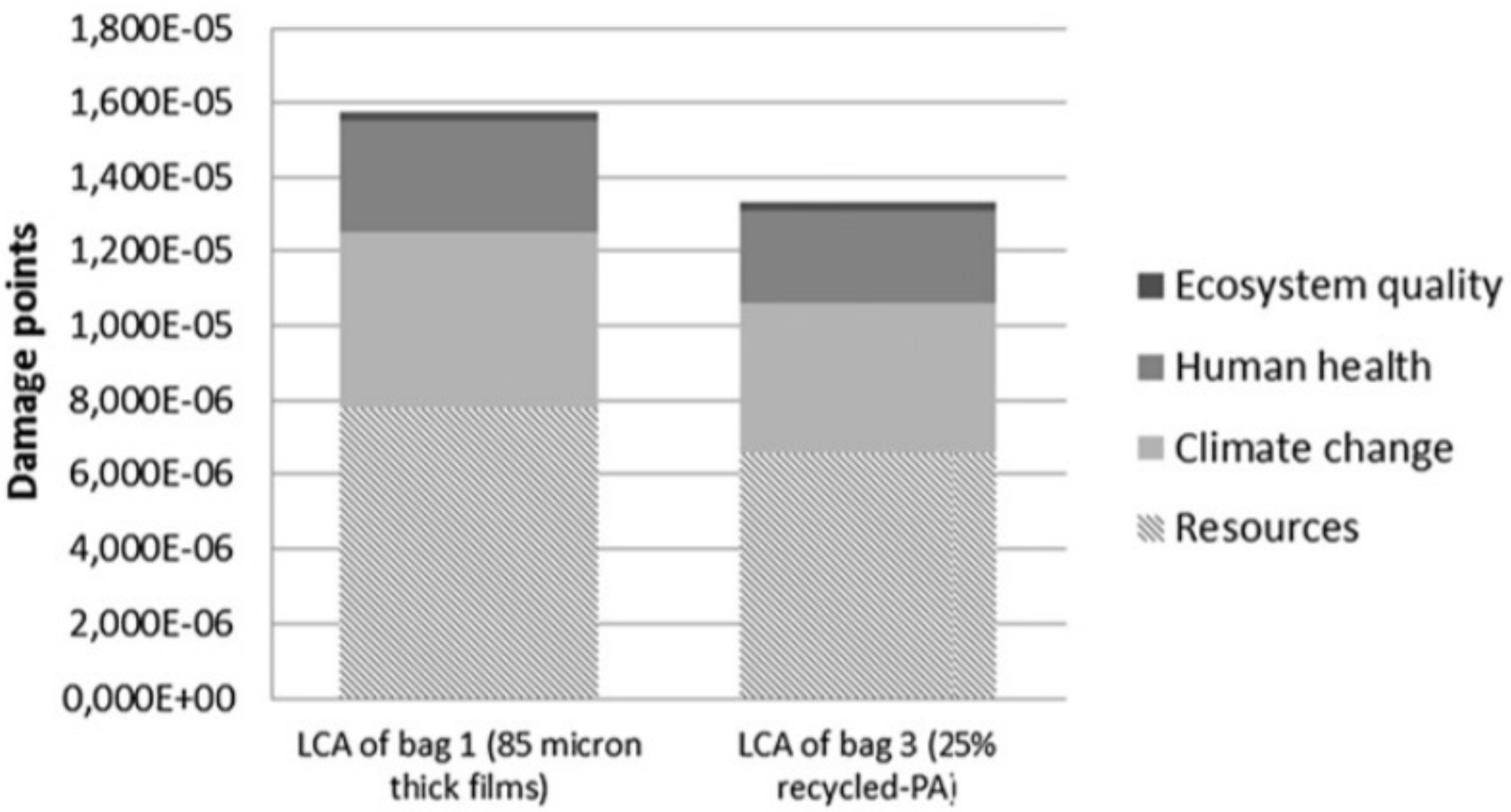
It would be much better to capture the embodied energy and material for reuse through recycling

Contents lists available at ScienceDirect
Food Research International
journal homepage: www.elsevier.com/locate/foodres

Environmental assessment of a multilayer polymer bag for food packaging and preservation: An LCA approach

Valentina Siracusa [a,1], Carlo Ingrao [b,*], Agata Lo Giudice [c,2], Charles Mbohwa [c,2], Marco Dalla Rosa [d,3]

LCA approach to consider resources consumption and impact of emissions (biodegradable vs. recycled)



by-products /waste valorization & reduction /Recovery of fuctional components

Bio-based ingredients for sustainable industries through biotechnology

AIMS

Selection of the most appropriate strain(s)/consortia in relation to the:

i) physico-chemical, composition and process features of each considered side stream/by-product;

ii) features of the end products to be obtained;

iii) constraints of scaling up at industrial level (yield, production rate);

iv) integration and acceptance of new biotechnologies in the existing industrial facilities;

v) competition with non bio-based compounds already available in the market.

Horizon 2020
European Union Funding
for Research & Innovation

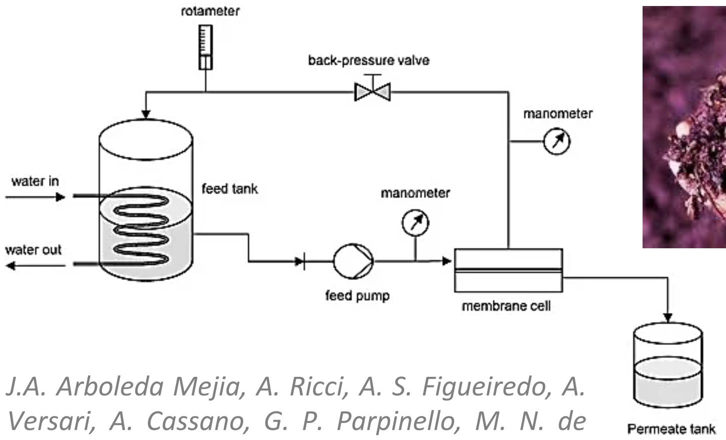
Bio-based Industries Consortium

BBI JU

INGREEN in the Top 50 for bio-based innovations

STA & BIOECONOMIA

Membrane-based Fractionation of Polyphenols and Polysaccharides From Winery Wastes (Pomaces and Sludges)



J.A. Arboleda Mejia, A. Ricci, A. S. Figueiredo, A. Versari, A. Cassano, G. P. Parpinello, M. N. de Pinho, Foods 2021;
J.A. Arboleda Mejia, A. Ricci, A. S. Figueiredo, A. Versari, A. Cassano, M. N. de Pinho, G. P. Parpinello, Food Bioproc Tech 2022

Key Background Issue:
Solid residues regarding wine production correspond to approximately 30% of the grapes used, which is represented in millions of tons of wastes with a strong environmental impact.

Technological challenge:
Use of ultrafiltration (UF) processes and laboratory-made, flat-sheet, cellulose acetate membrane for nanofiltration (NF) in a sequential design and sustainable process to fractionate and refine phenolic compounds from winery sludge, to obtain concentrated fractions with high antioxidant activities.

Valorisation of by-products from the wine industry in the production of high-quality supplements

Encapsulation of bioactive polyphenolic compounds recovered by nanofiltration of wine lees with maltodextrin to obtain a spray dried micro powder with enhanced nutritional value. *In–vitro* simulated digestion performed under physiological conditions evidenced **bioaccessibility of polyphenols from microencapsulates** → **potential for the absorption at gastrointestinal level.**

A. Ricci, J.A. Arboleda Mejia, A. Versari, E. Chiarello, A. Bordoni, G.P. Parpinello, Food Bioprod Process 2022

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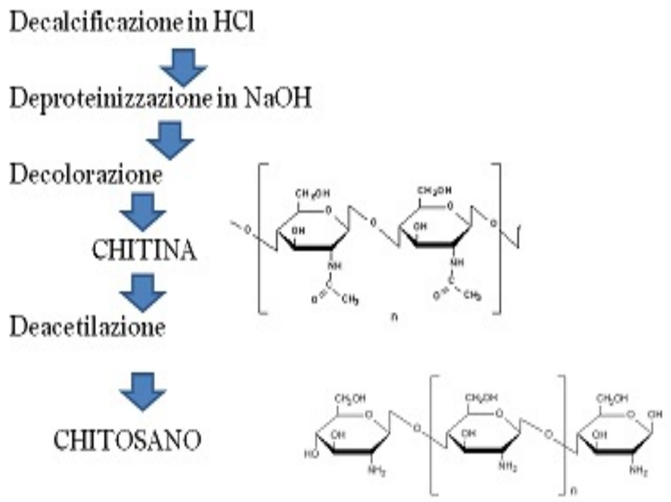
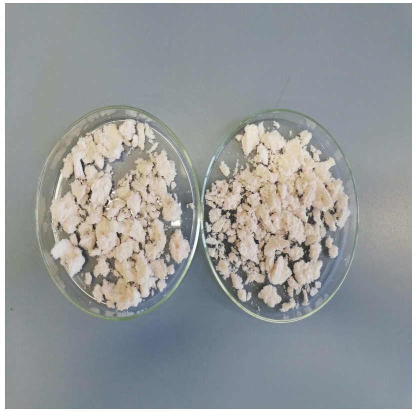
STA & BIOECONOMIA

Chitin and Chitosan extraction from crustacean carapace

PhD Thesis Ana Cristina De Aguiar Saldanha Pinheiro

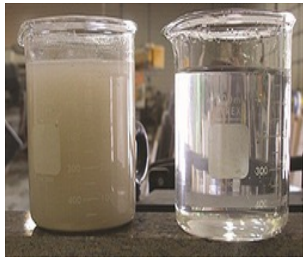




Extraction from carapace of mantis shrimp:
Yield ≈ 10%

- ✓ **Food industry applications of chitosan:**

- ✓ **Antioxidant**
- ✓ **Emulsifying agent**
- ✓ **Edible film/coating**
- ✓ **Flocculating and clarifying agent**
- ✓ **Food Preservative:**
- ✓ **Antimicrobial and antifungal properties**
- ✓ **Food fiber**
- ✓ **Immobilization of enzymes**
- ✓ **Additive - stabilization of color, texture, odor**



Evaluation of innovative non-thermal technologies (Ultrasound, Pulsed Electric Fields, Plasma) for modulating the molecular weight and thus the characteristics of extracted chitosan

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Food Crossing District

Two new foods from by-products and a map of related circular economies in Emilia-Romagna

coordinator Tullia Gallina Toschi

- Use and valorization of by-products → optimization of technological processes
- Obtaining new functional products

Value chain: TOMATO
By-Product: PEELS and seeds

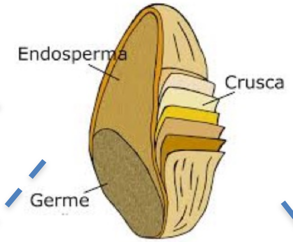
Olives

Peels and seeds of tomato

Seasoning obtained by co-crushing

Value chain: WHEAT
By-Product: BRAN

Wheat Germ



Wheat germ oil

Fuels

De-fatted bran

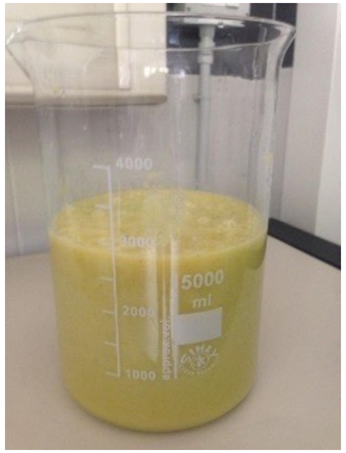
Il progetto FOOD CROSSING DISTRICT è co-finanziato dal Fondo europeo di sviluppo regionale POR FESR 2014-2020

PRODUCTS OBTAINED ON A PILOT / SEMI-INDUSTRIAL SCALE

Slices of kiwifruit treated with OD and dried at low temperature

kiwifruit Puree di kiwifruit stabilized with HPH

97°C, 25 min	HPH	70°C + HPH



Dried snacks - Different formulations of kiwifruit with other ingredients


molecules

MDPI

Article

Design of Healthy Snack Based on Kiwifruit

Urszula Tylewicz [1,2], Malgorzata Nowacka [3,*], Katarzyna Rybak [3], Kinga Drozdzal [3], Marco Dalla Rosa [1,2] and Massimo Mozzon [4]

Toward a More Sustainable Diet

alternative feed & food / alternative protein based products / reformulation

Alternative protein sources

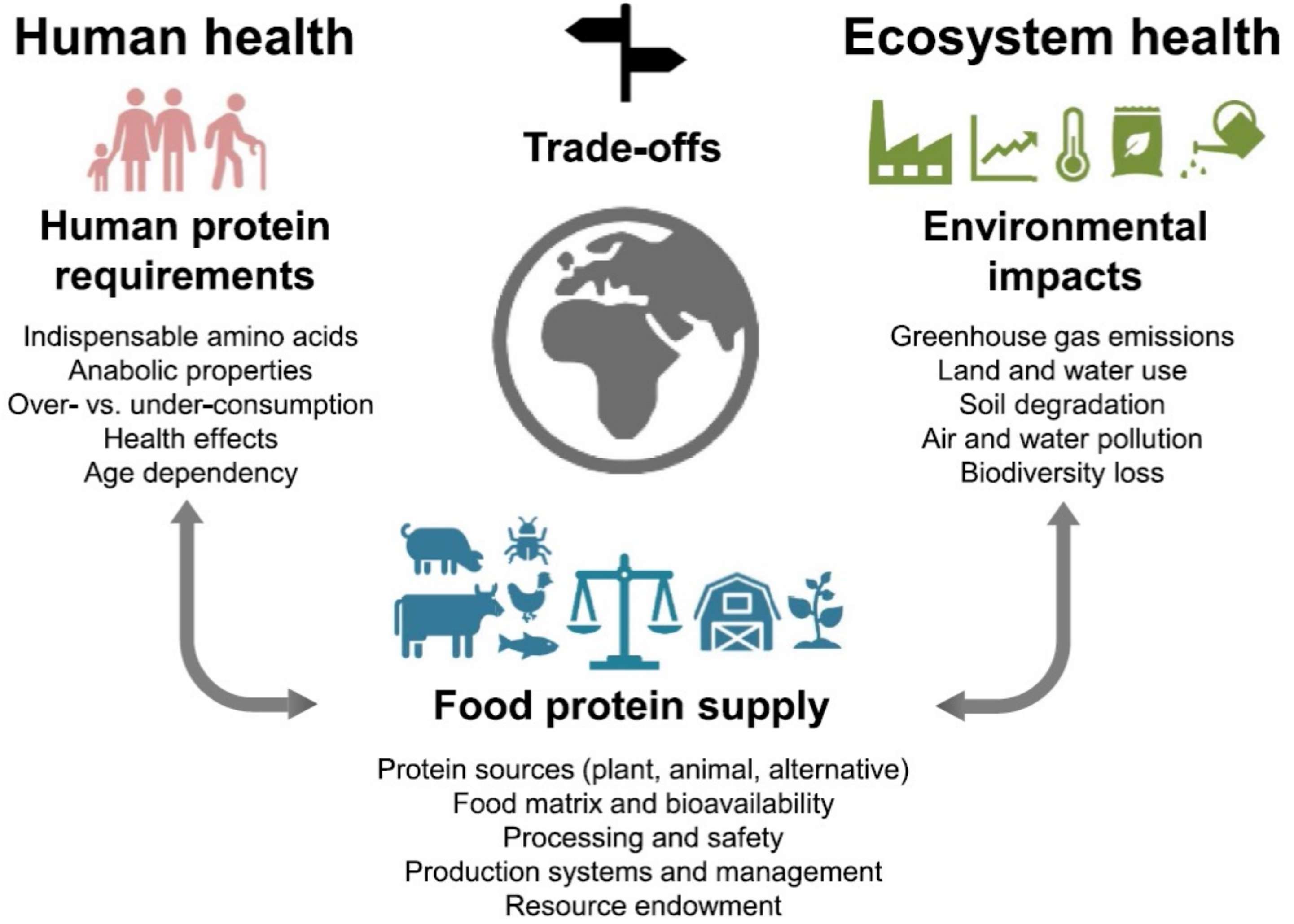


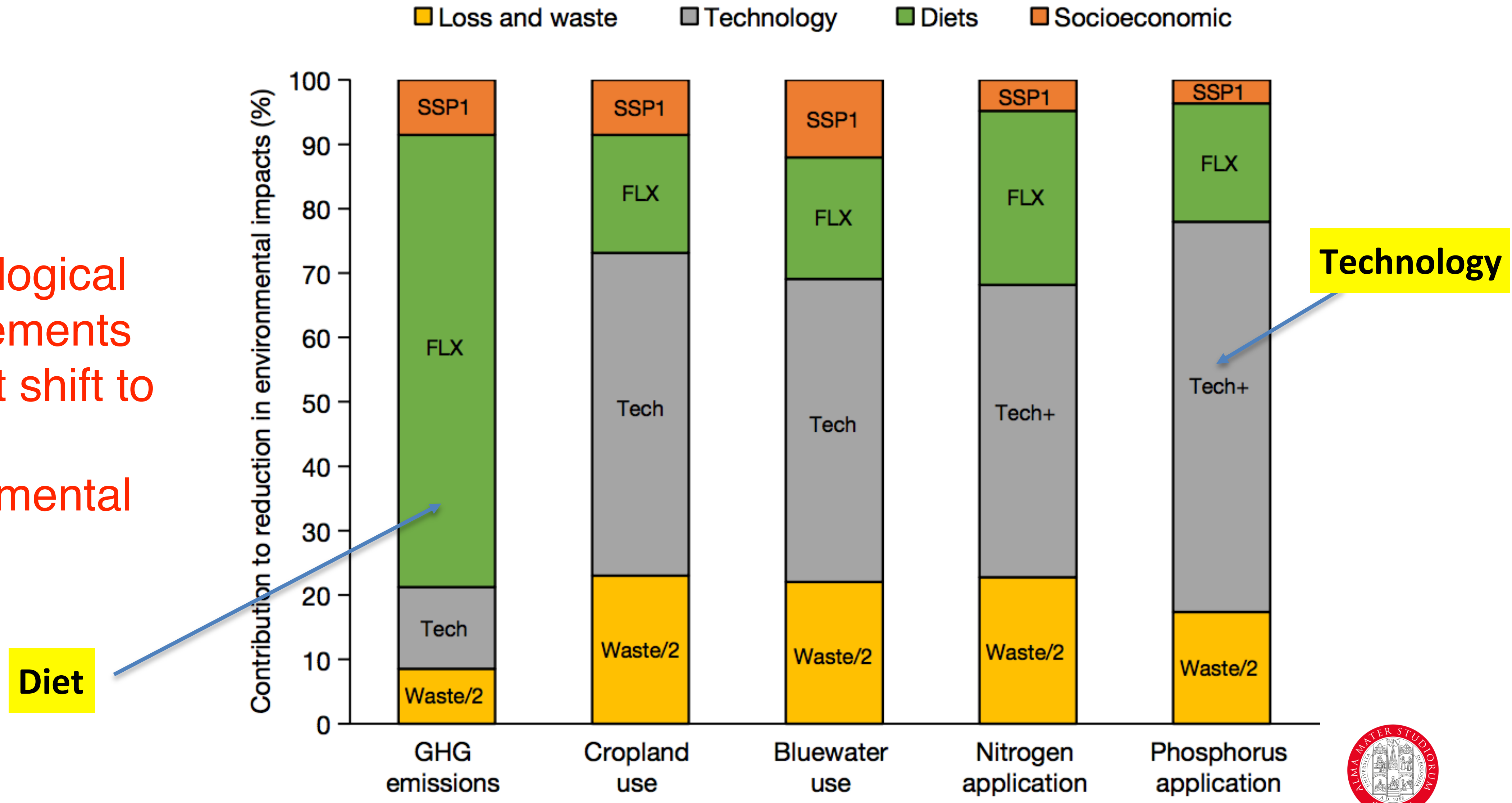
Fig. 1. Sustainable food protein supply at the intersection of human and ecosystem health.

Weindl, I.; Ost; M.; Wiedmer, P.; Schreiner, M.; Neugart, S.; Klopsch, R.; Kühnhold, H.; Kloas, W.; Henkel, I.M. Schlüter, O.; Bußler, S.; Bellingrath-kimura, S.D.; Ma, H.; Grune, T.; Rolinski, S. And Klaus, S. (2020) Sustainable food protein supply reconciling human and ecosystem health: A Leibniz Position. Global Food Security. Volume 25, June 2020, 100367 (https://doi.org/10.1016/j.gfs.2020.100367).

By courtesy of O.Schlüter - ATB

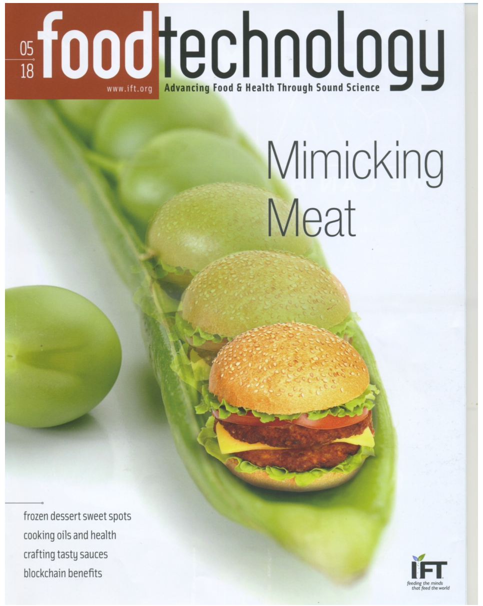
Impact of changes in food production on global environmental p

Role of Technological improvements and diet shift to reduce environmental impact

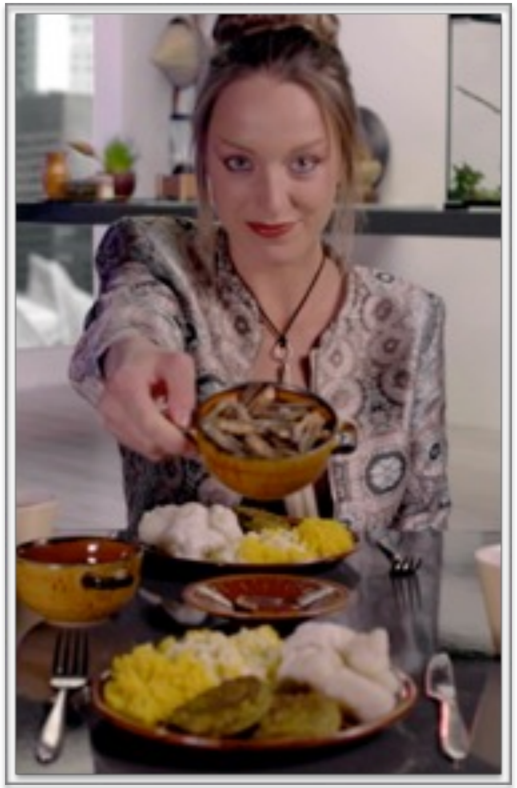


Springmann et al., Nature, 2018

Utilizzo proteine alternative alimenti “plant based”



…….e proteine alternative <u>animali</u> a basso impatto



More sustainable Proteic sources

ELSEVIER

Contents lists available at ScienceDirect

LWT - Food Science and Technology

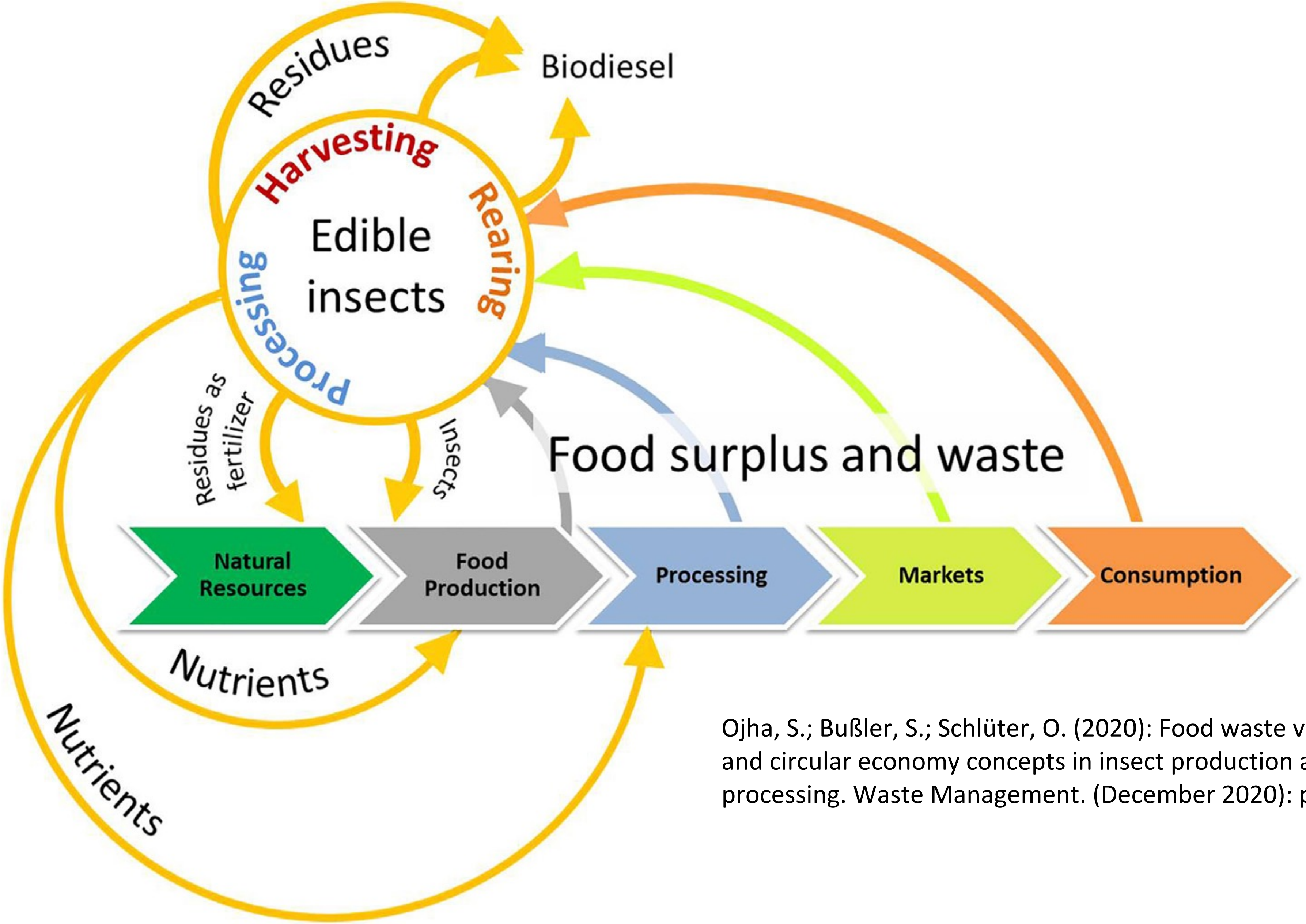
journal homepage: www.elsevier.com/locate/lwt

Potential of *Yarrowia lipolytica* and *Debaryomyces hansenii* strains to produce high quality food ingredients based on cricket powder

Check for updates

Francesca Patrignani[a,b], Luigi Parrotta[c], Stefano Del Duca[b,c], Lucia Vannini[a,b], Lucia Camprini[a], Marco Dalla Rosa[a,b], Oliver Schlüter[d,**], Rosalba Lanciotti[a,b,*]

great potential of all the yeast strains used to produce cricket based food ingredients endowed with improved safety, functionality, sensory and technological properties.



Ojha, S.; Bußler, S.; Schlüter, O. (2020): Food waste valorisation and circular economy concepts in insect production and processing. Waste Management. (December 2020): p. 600-609.

Adeguamento ricette e prodotti tipici alle esigenze PAN

nuovi prodotti nuovi target
filiera Parmigiano Reggiano

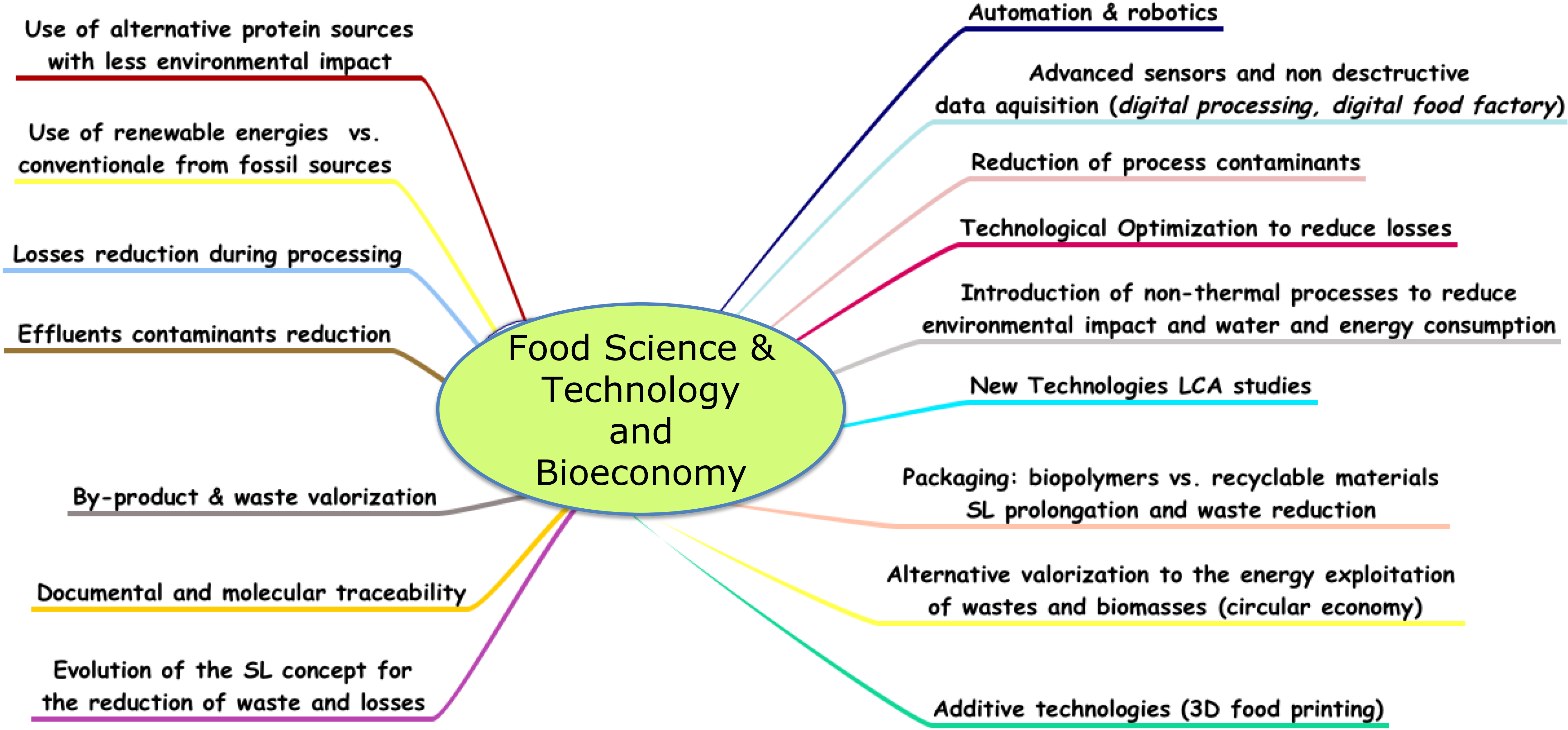
Formaggio PR iposodico

Specifiche di produzione per i caseifici per ottenere un formaggio con meno NaCl, ma di gusto tipico.

Green Charcuterie

Preservare i nutrienti della carne fino al consumo

Aggiungere valore nutrizionale grazie al processo di lavorazione


Food Science & Technology and Bioeconomy
Use of alternative protein sources with less environmental impact
Use of renewable energies vs. conventionale from fossil sources
Losses reduction during processing
Effluents contaminants reduction
By-product & waste valorization
Documental and molecular traceability
Evolution of the SL concept for the reduction of waste and losses
Automation & robotics
Advanced sensors and non desctructive data aquisition (*digital processing, digital food factory*)
Reduction of process contaminants
Technological Optimization to reduce losses
Introduction of non-thermal processes to reduce environmental impact and water and energy consumption
New Technologies LCA studies
Packaging: biopolymers vs. recyclable materials SL prolongation and waste reduction
Alternative valorization to the energy exploitation of wastes and biomasses (circular economy)
Additive technologies (3D food printing)

Le scienze e tecnologie alimentari nella bioeconomia

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SISTAL
SOCIETA' ITALIANA DI SCIENZE E TECNOLOGIE ALIMENTARI

Grazie per l'attenzione

Marco Dalla Rosa

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