SCUOLA DI AGRARIA E MEDICINA VETERINARIA 2023

IL caffè SCIENTIFICO

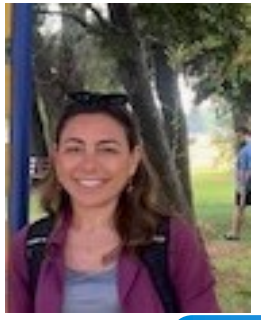
Coating e film attivi a base di biopolimeri per preservare la sicurezza e qualità degli alimenti

Elena Torrieri

19 Aprile, 2023

Dipartimento di Agraria

Università degli Studi di Napoli Federico II

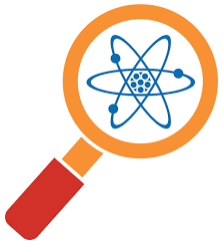


Mi presento!

2000 — 2002 — 2003 — 2005 — 2012-2013 — 2014 — 2023

Laurea in Scienze e Tecnologie Alimentari

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh



PhD-Scienze e Tecnologie Agroalimentari

Ricercatore AGR/15

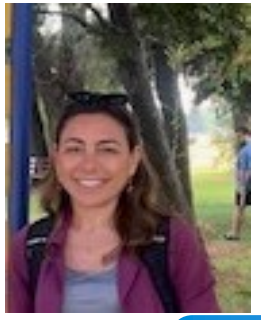
UNIVERSITÉ MONTPELLIER 2
SCIENCES ET TECHNIQUES

Professore Associato AGR/15

Didattica:

- ✓ Elementi di Packaging (TAL)
- ✓ Tecnologie del confezionamento e della distribuzione dei prodotti alimentari (STAL)
- ✓ Kinetics approach to predict the shelf life of Food (PhD Food Science)
- ✓ Sustainable food processing and packaging (Sustainable Food Systems)

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II



I miei interessi

Sfide

Alimenti freschi ma con shelf-life adatta ai nuovi stili di vita

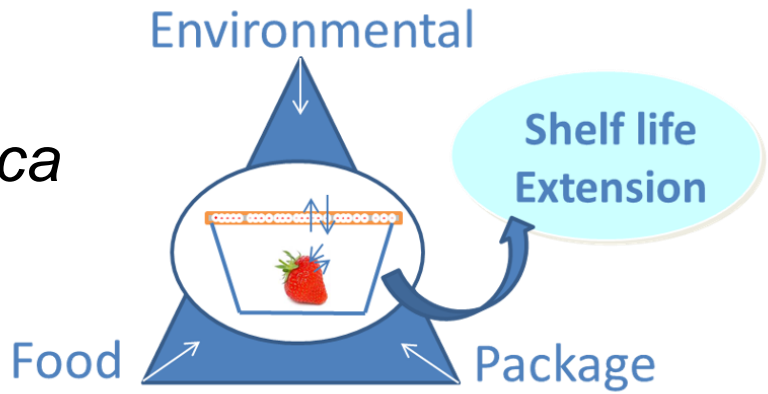
Economia circolare

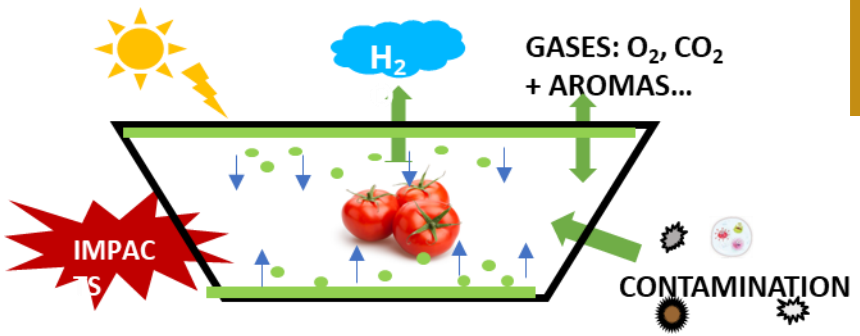
2 SCONFIGGERE LA FAME

12 CONSUMO E PRODUZIONE RESPONSABILI

2003 **2009** **2015** **2023**

Ricerca





Cosa sono gli imballaggi Attivi?

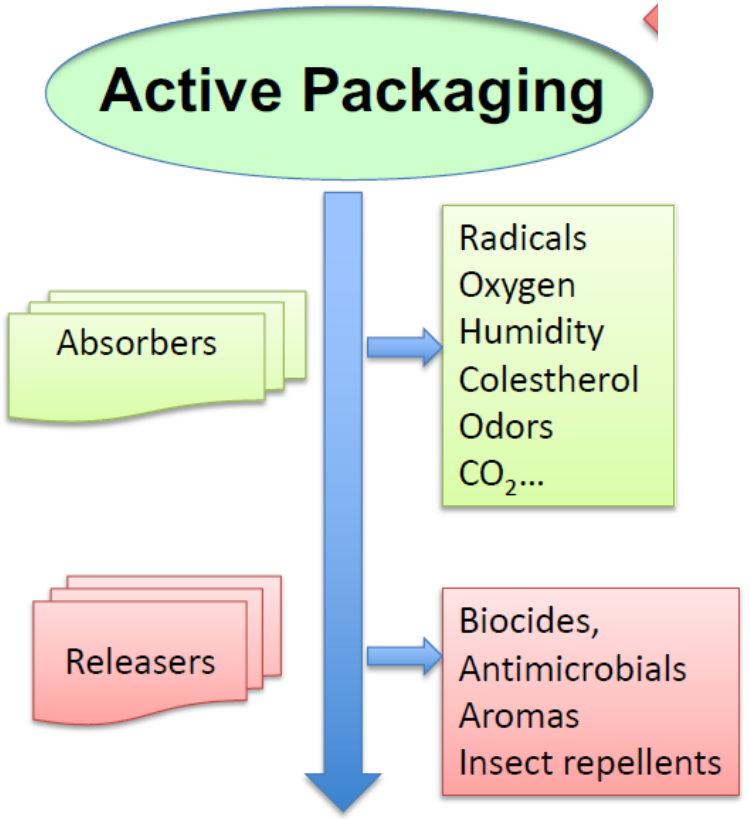
L 338/4 IT Gazzetta ufficiale dell'Unione europea 13.11.2004

REGOLAMENTO (CE) N. 1935/2004 DEL PARLAMENTO EUROPEO E DEL CONSIGLIO

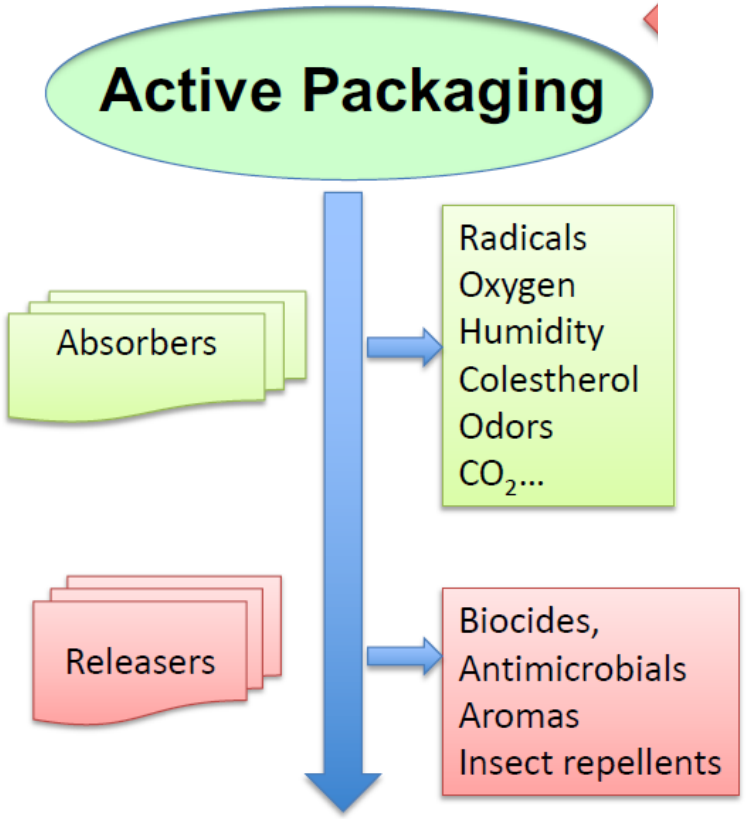
del 27 ottobre 2004

riguardante i materiali e gli oggetti destinati a venire a contatto con i prodotti alimentari e che abroga le direttive 80/590/CEE e 89/109/CEE

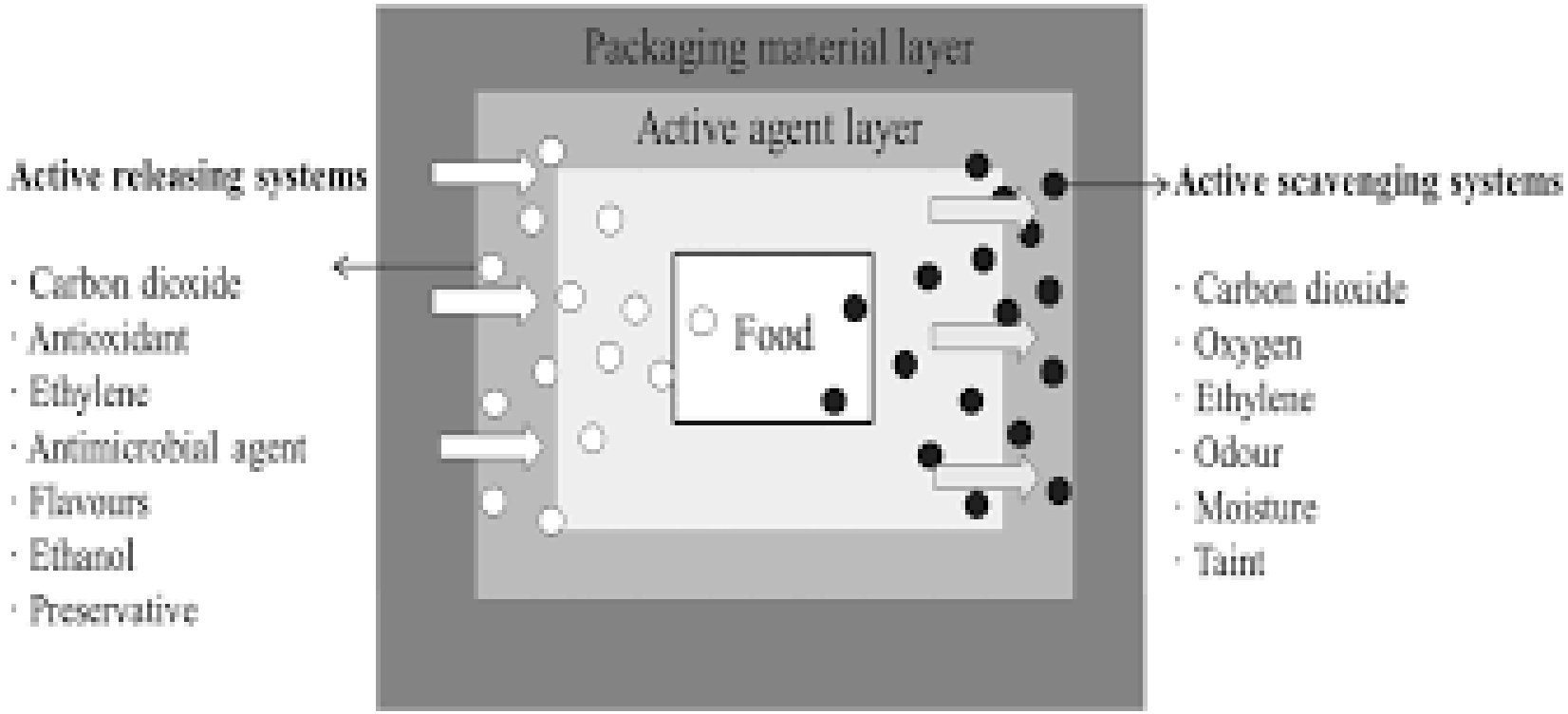
«per materiali e oggetti attivi .....s'intendono materiali e oggetti destinati a prolungare la conservabilità o mantenere o migliorare le condizioni dei prodotti alimentari imballati. Essi sono concepiti in modo da incorporare deliberatamente componenti che rilascino sostanze nel prodotto alimentare imballato o nel suo ambiente, o le assorbano dagli stessi»



Come rendere un imballaggio attivo



Perchè utilizzare gli imballaggi Attivi?



Trends in Food Science & Technology 112 (2021) 690–707

Contents lists available at ScienceDirect

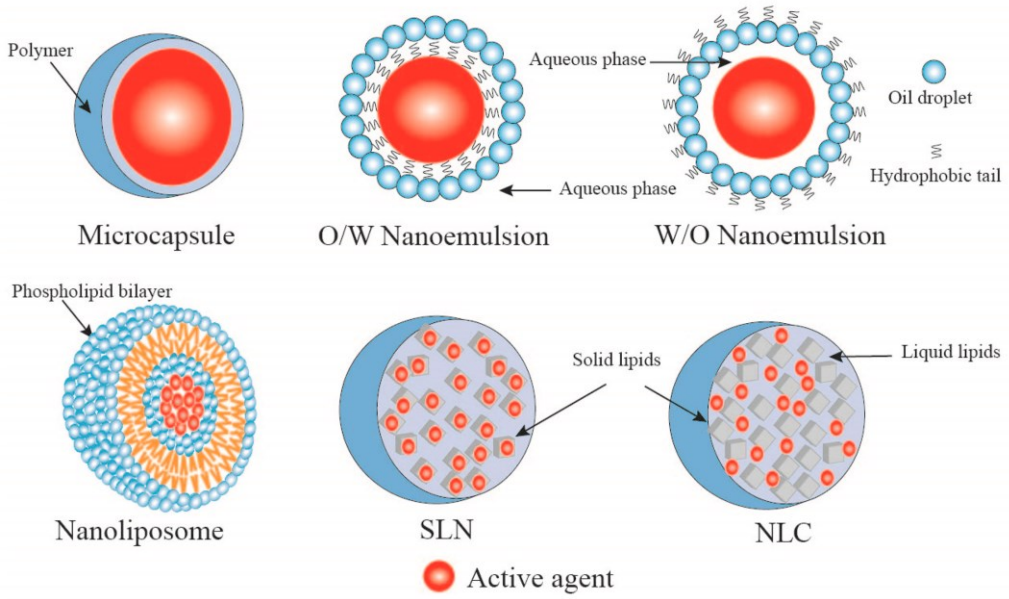
Trends in Food Science & Technology

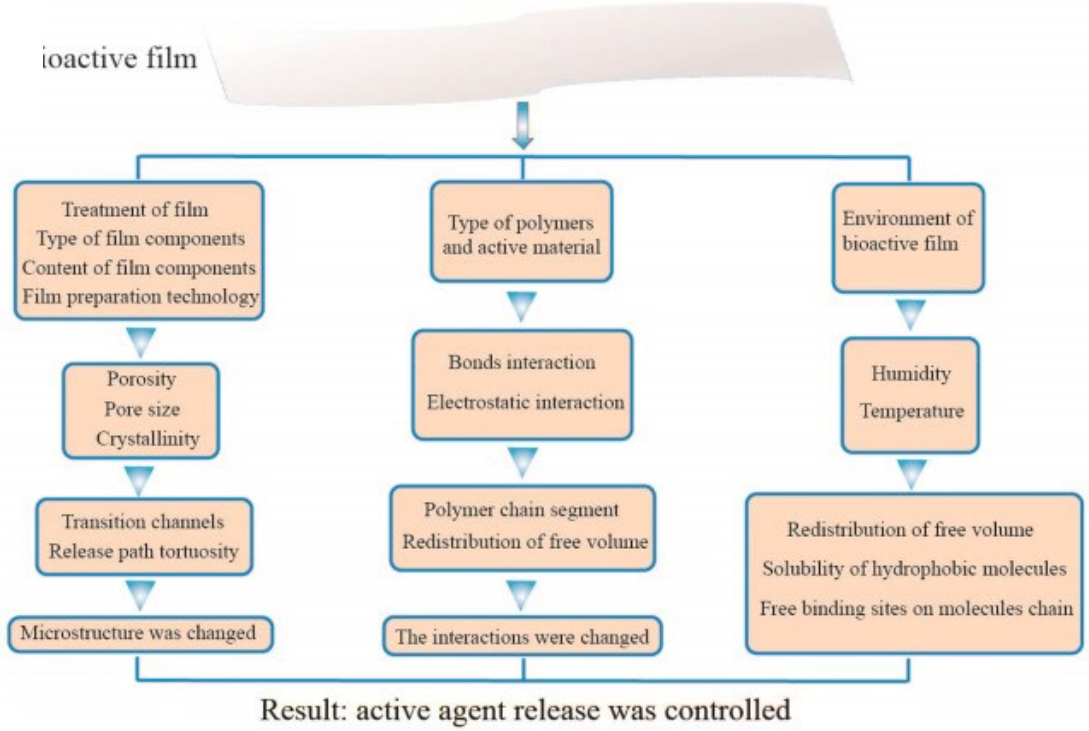
journal homepage: www.elsevier.com/locate/tifs

A comprehensive review on natural bioactive films with controlled release characteristics and their applications in foods and pharmaceuticals

Liming Zhang [a,b], Dawei Yu [a,b,*], Joe M. Regenstein [b,c], Wenshui Xia [a,b,**], Junli Dong [a,b]

[a] State Key Laboratory of Food Science and Technology, School of Food Science and Technology, Jiangnan University, Wuxi, Jiangsu, 214122, China
[b] Collaborative Innovation Center of Food Safety and Quality Control in Jiangsu Province, Jiangnan University, Wuxi, Jiangsu, 214122, China
[c] Department of Food Science, Cornell University, Ithaca, NY, 14853-7201, USA





Carrier di agenti attivi

Progettazione di nuovi sistemi di imballaggio:

Film Attivi a rilascio controllato

Innovative Food Science and Emerging Technologies 42 (2017) 64–72

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

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

A mathematical model for tailoring antimicrobial packaging material containing encapsulated volatile compounds

Mia Kurek[a], Yannick Laridon[a], Elena Torrieri[b], Valérie Guillard[a,*], Astrid Pant[c], Cornelia Stramm[c], Nathalie Gontard[a], Carole Guillaume[a]

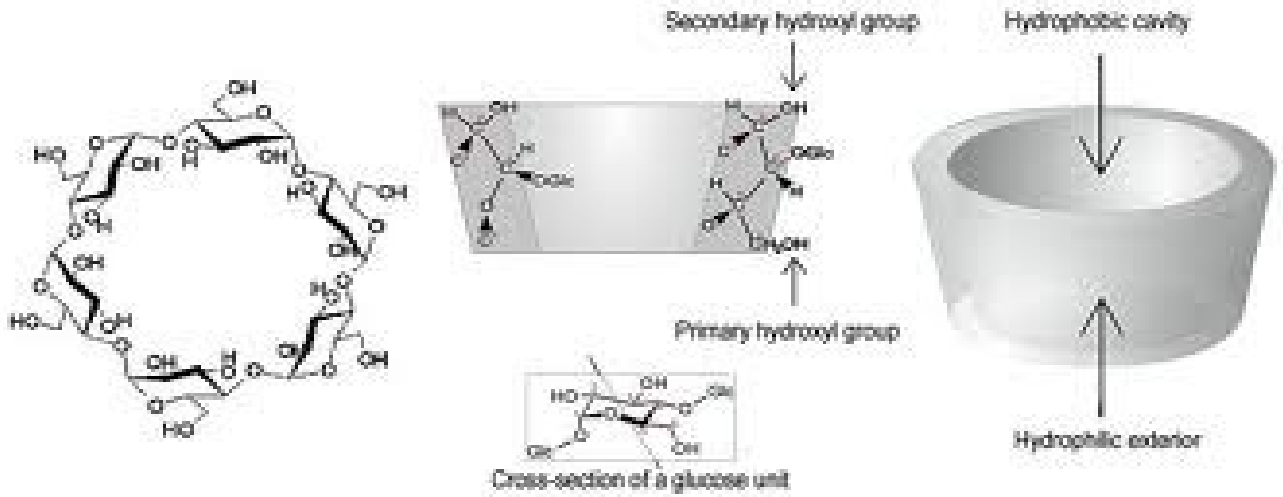
[a] Joint Research Unit Agropolymers Engineering and Emerging Technologies, UMR 1208 INRA/SupAgroM/UM/CIRAD, 2 Place Pierre Viala, 34060 Montpellier, France
[b] Food Science and Agricultural Department, University of Naples Federico II, Via Università 100, 80055 Portici, NA, Italy
[c] Fraunhofer IVV Institute for Process Engineering and Packaging, Giggenhauser Straße 35, Freising, Germany

"POR CAMPANIA FSE 2007/2013" - project CARINA (safety sustainability and competitiveness of the agro-food production in Campania).

NEXT GENERATION OF PACKAGING

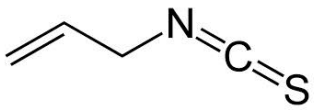
Rilascio controllato

β-CYCLODEXTRIN (CD)



$$CD\text{-}H_2O + AITC \rightleftharpoons CD\text{-}AITC + H_2O$$

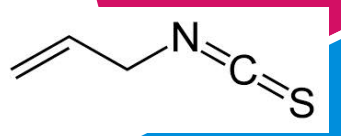
AITC

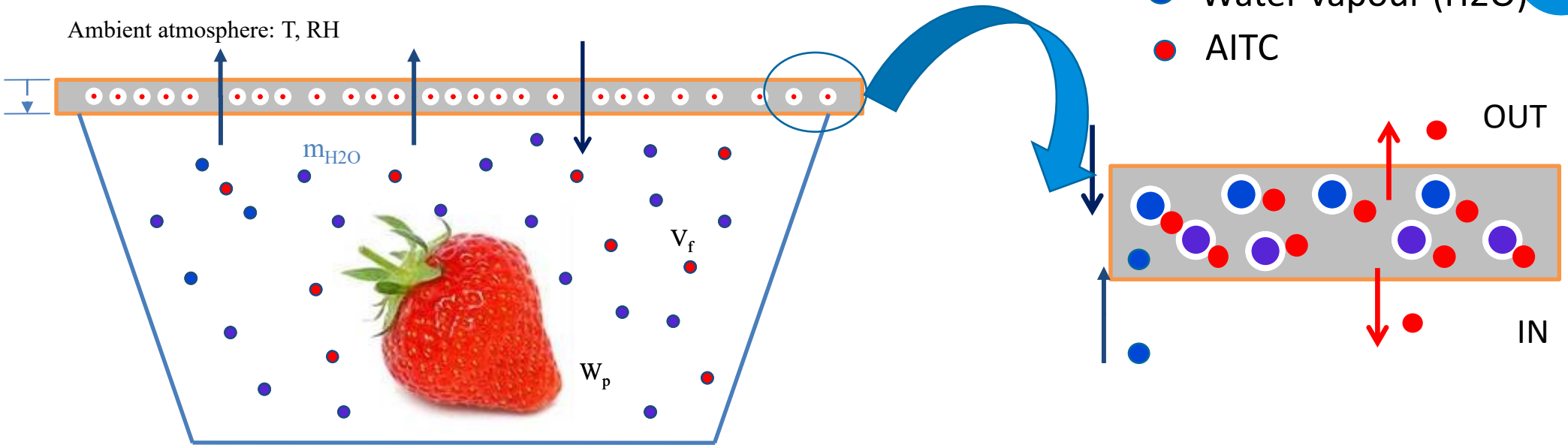


ACTIVE FILM

Progettazione di nuovi sistemi di imballaggio: Film Attivi a rilascio controllato

AITC





β-CD-AITC

Water vapour (H2O)

AITC

1) Water trasport

$$\frac{\partial C_i}{\partial t} = D_i \frac{\partial^2 C_i}{\partial x^2}$$

2) Reaction

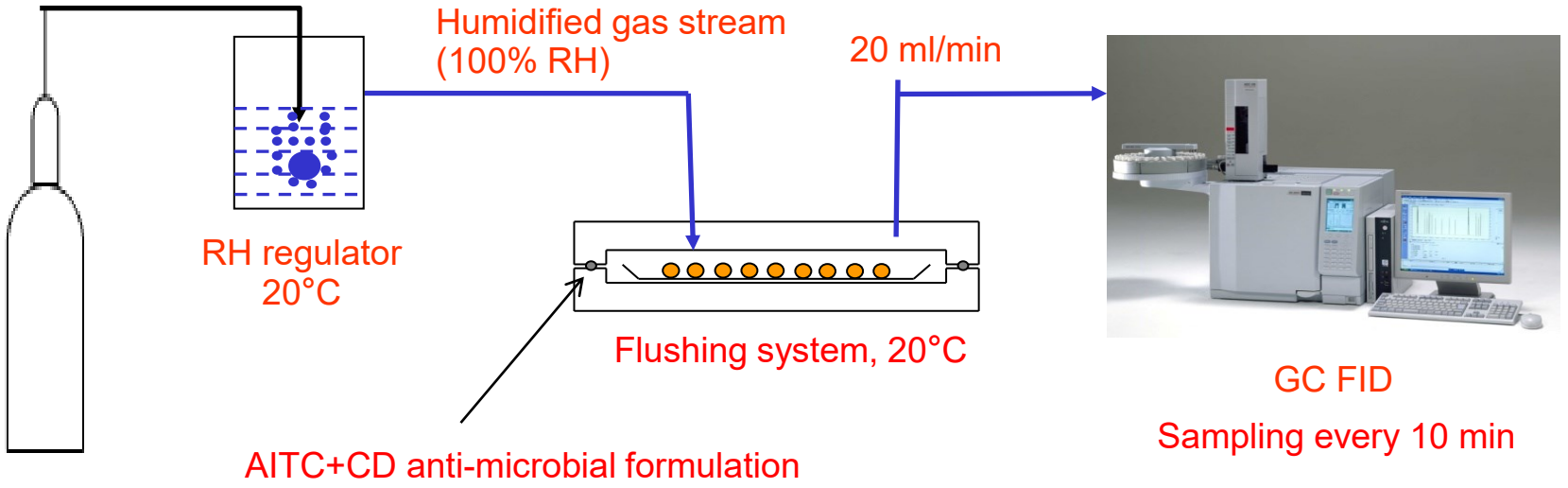
CD-AITC + H_2O ⟶ CD-H2O + AITC

$$\frac{\partial C_j}{\partial t} = -rC_j$$

3) AITC tranport

$$\frac{\partial C_z}{\partial t} = D_i \frac{\partial^2 C_z}{\partial x^2} + rC_j$$

Progettazione di nuovi sistemi di imballaggio: Film Attivi a rilascio controllato



GC FID

Sampling every 10 min

Test conditions:

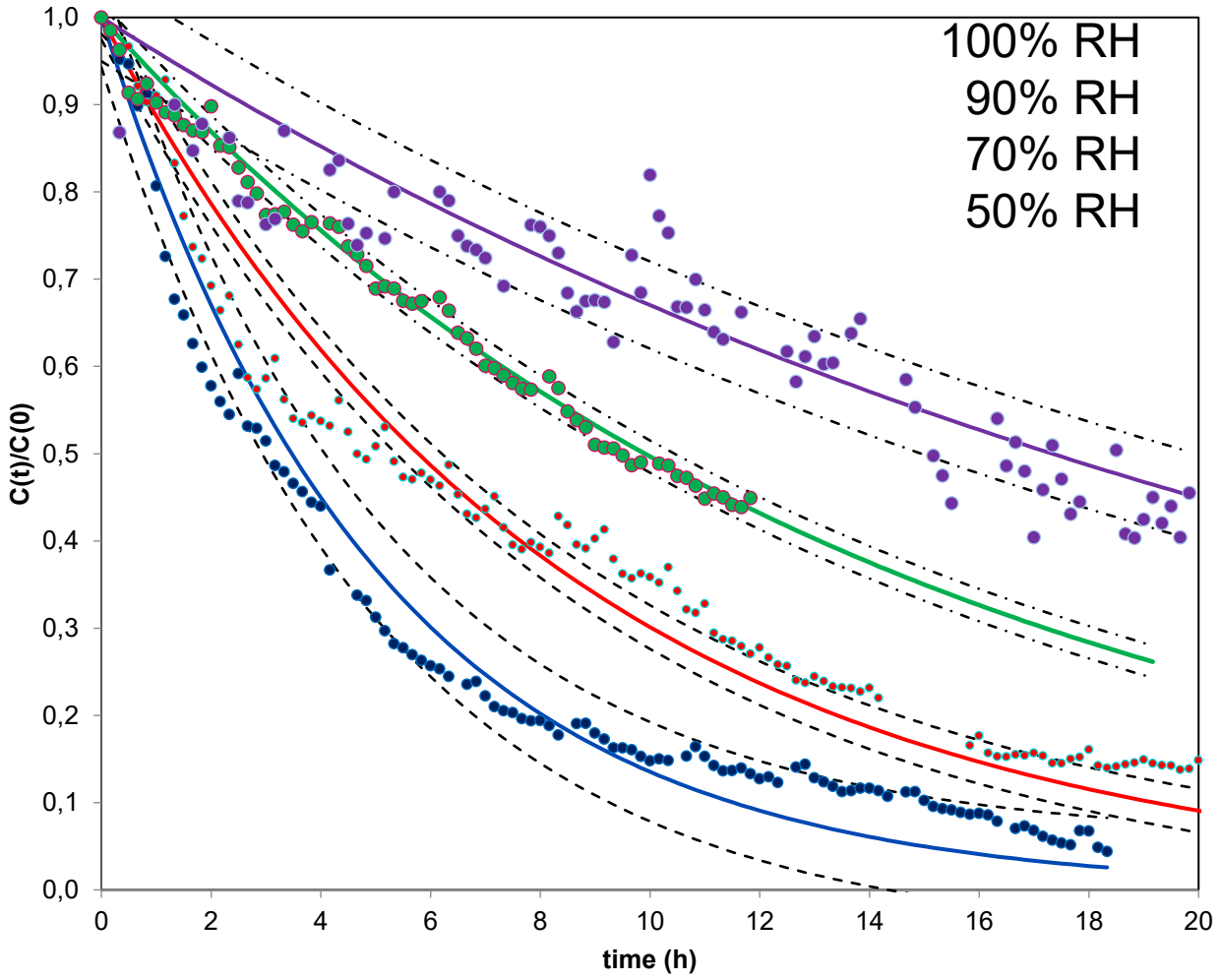
50%
60%
70%
80%
90%
100%

$$-\frac{d[AITC]}{dt} = k_{app}[AITC]n$$

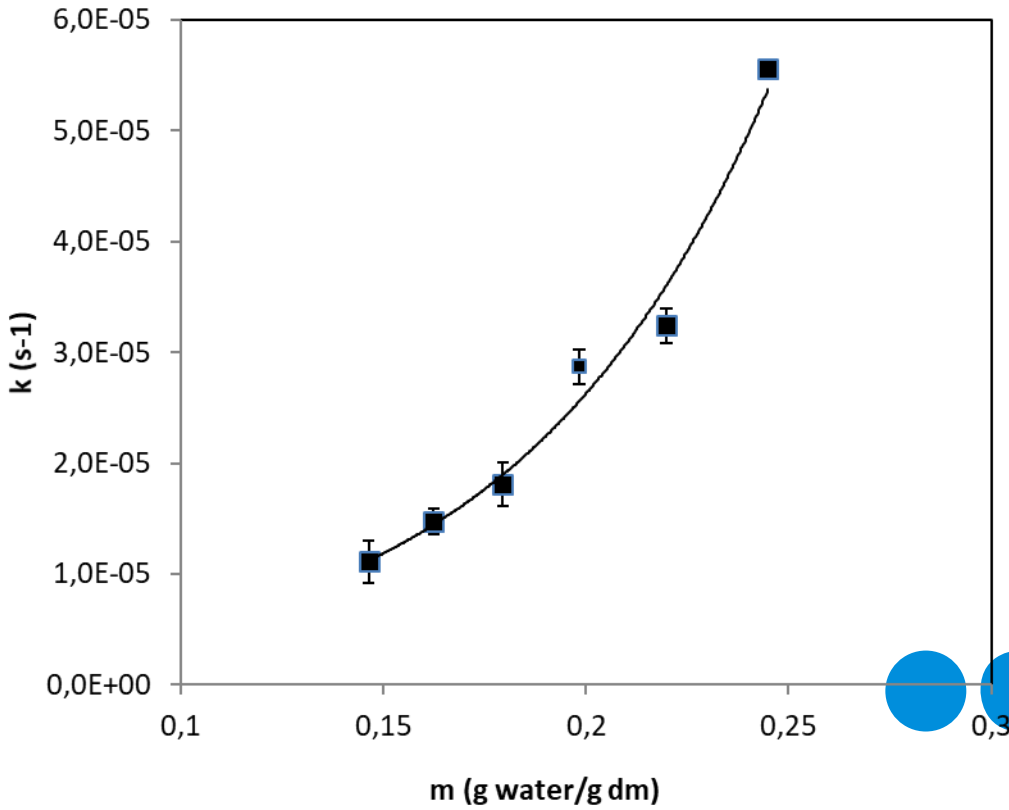
with

$$k_{app} = f(RH)$$

Progettazione di nuovi sistemi di imballaggio: Film Attivi a rilascio controllato



$$\frac{\partial C_j}{\partial t} = -rC_j$$



Progettazione di nuovi sistemi di imballaggio: Film Attivi a rilascio controllato

At x = 0,

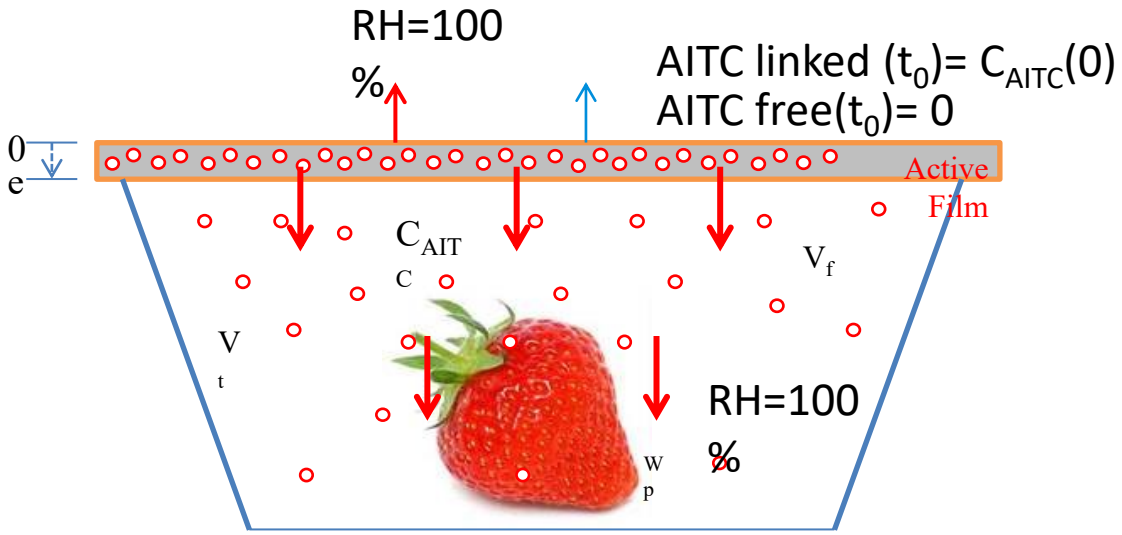
$$\begin{cases} D_i \dfrac{\partial C_{i(0,t)}}{\partial x} = \dfrac{\varphi_{ifilm}}{S_f} \\ \dfrac{\partial C_{j(0,t)}}{\partial x} = -rC_j \\ D_i \dfrac{\partial C_{z(0,t)}}{\partial x} = \dfrac{\varphi_{zfilm}}{S_f} + rC_j \end{cases}$$

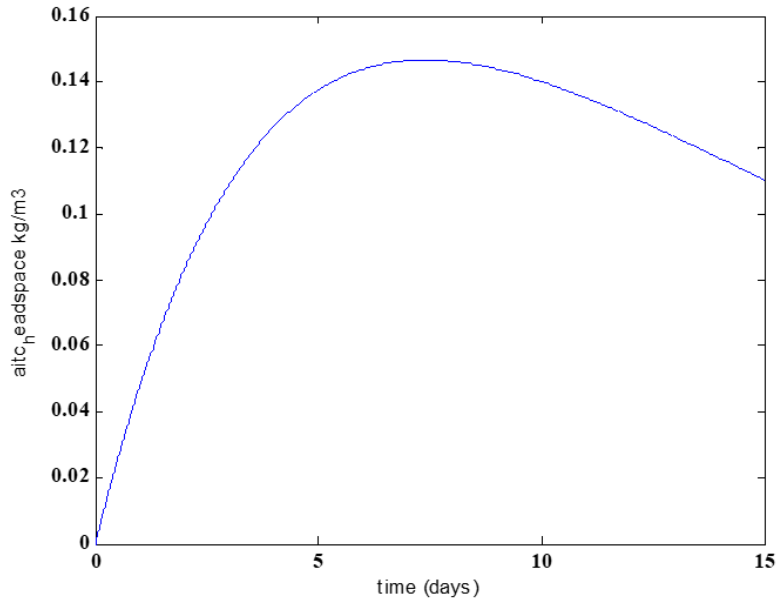
At x = e,

$$\begin{cases} D_i \dfrac{\partial C_{i(e,t)}}{\partial x} = \dfrac{\varphi_{ifilm}}{S_f} \\ \dfrac{\partial C_{j(e,t)}}{\partial x} = -rC_j \\ D_z \dfrac{\partial C_{j(e,t)}}{\partial x} = \dfrac{\varphi_{zfilm}}{S_f} + rC_j \end{cases}$$

At HS,

$$\begin{cases} V_{hs} \dfrac{\partial C_{AITC,hs}}{dt} = \varphi_{AITC,f} \\ V_{hs} \dfrac{\partial C_{w,hs}}{dt} = \varphi_{w,f} \end{cases}$$





ODE solver using Matlab

Performance!

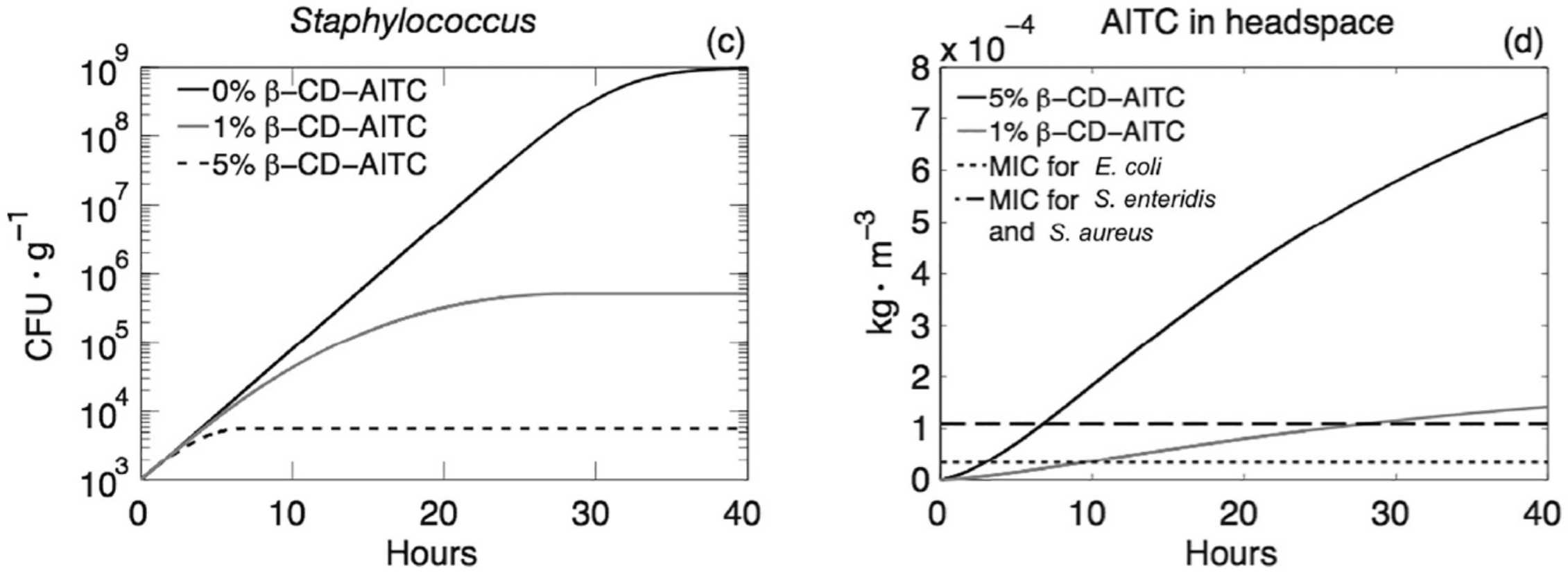
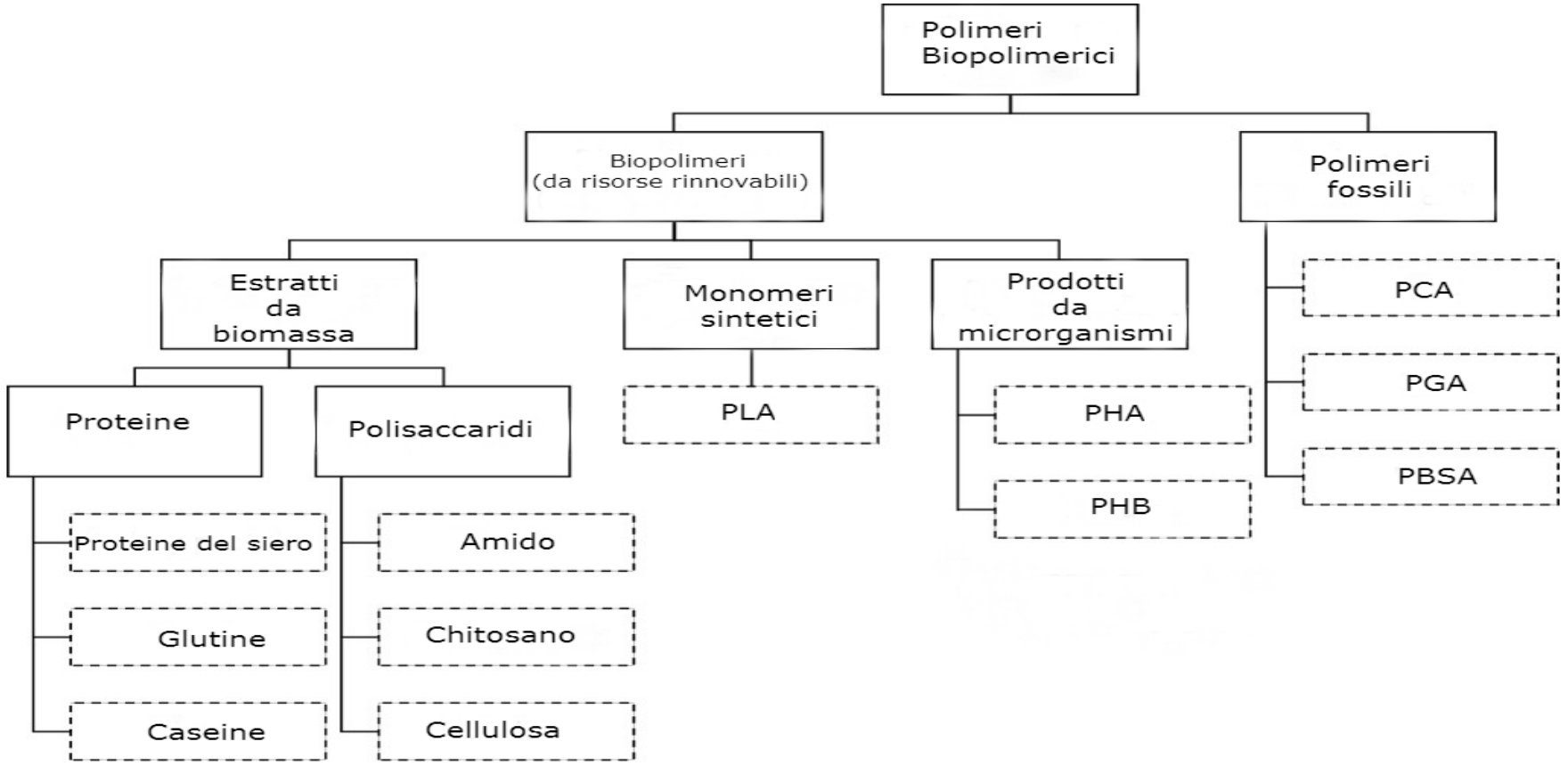
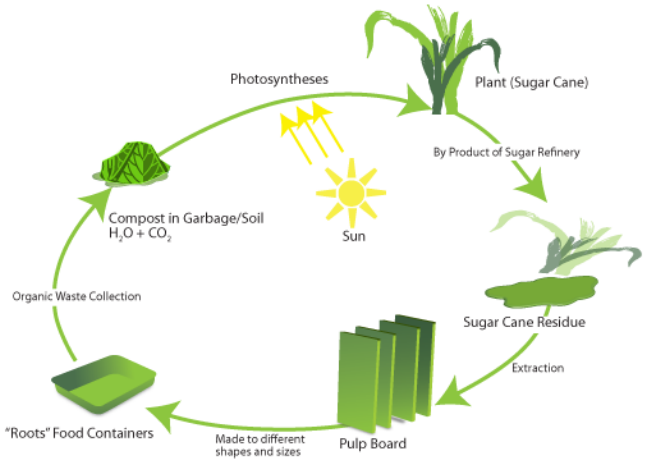


Fig. 7. Variation of microbial growth with AITC content (a, b, c) and AITC content in the headspace (d).

..... Coating e film attivi a base di biopolimeri





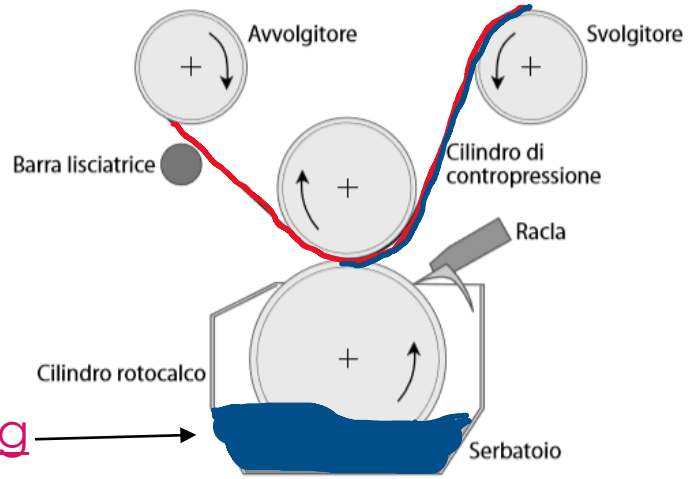
Film attivi antiossidanti

Chitosan/Sodium caseinate/REO

+

a) Polyammide
b) Polybutylene succinate film

→ Rotocalco technology = Layer by layer active film

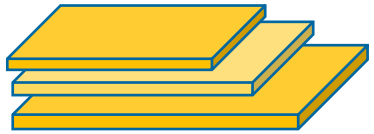


Active coating →

Amount of solid deposited
0.1mg/cm^2

Single layer

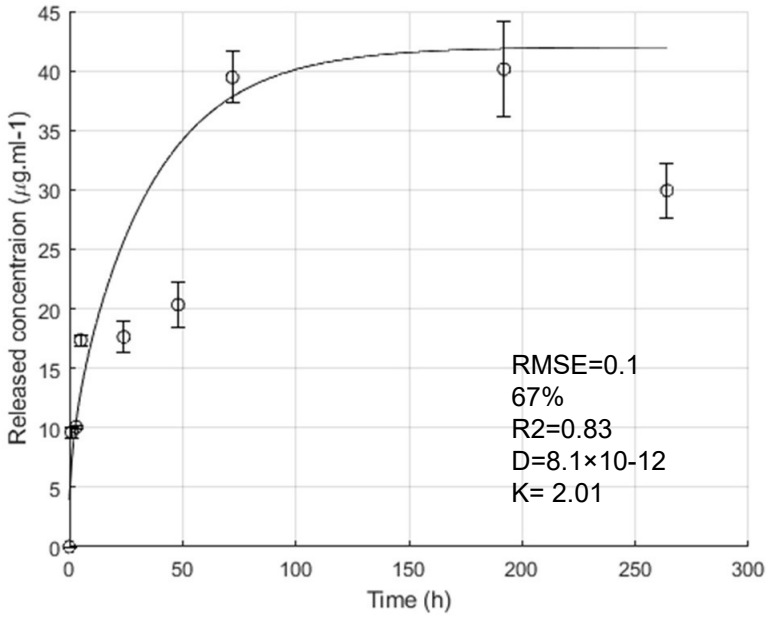
0,4 mg/cm^2

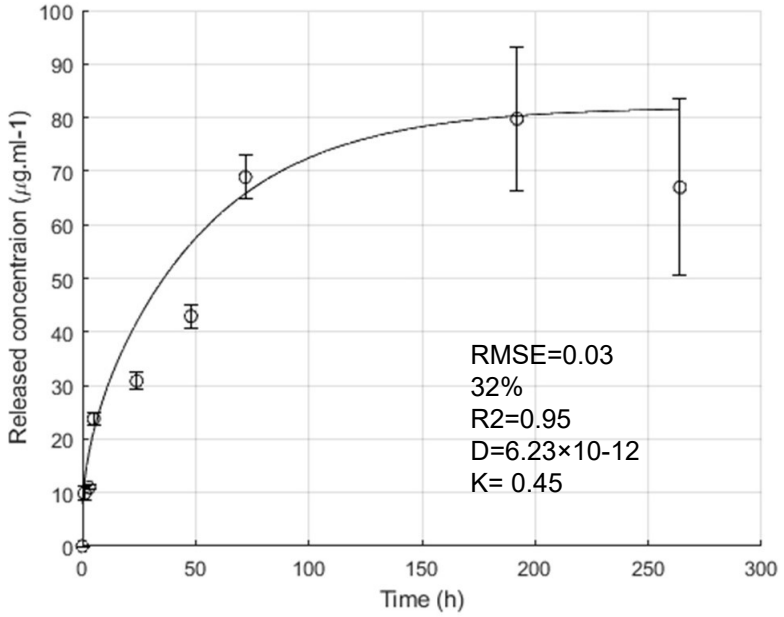


multilayer

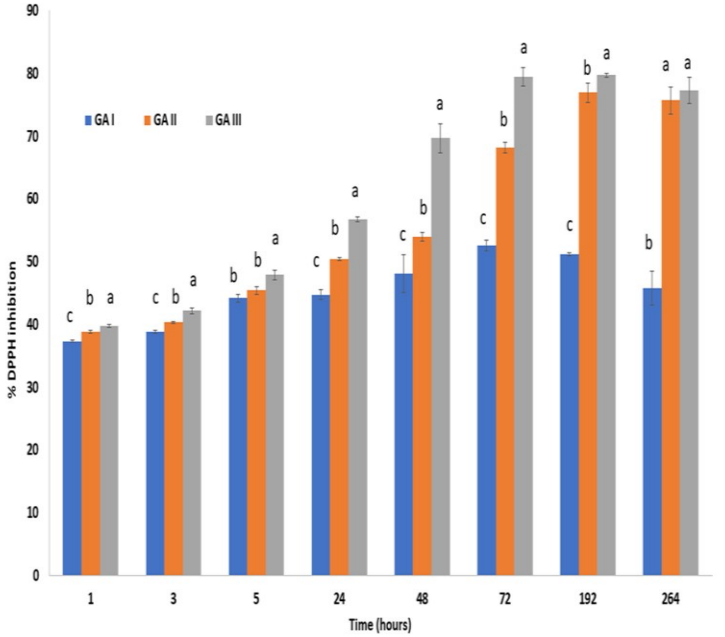
Theoretical antioxidant activity= 40% I(DPPH test)

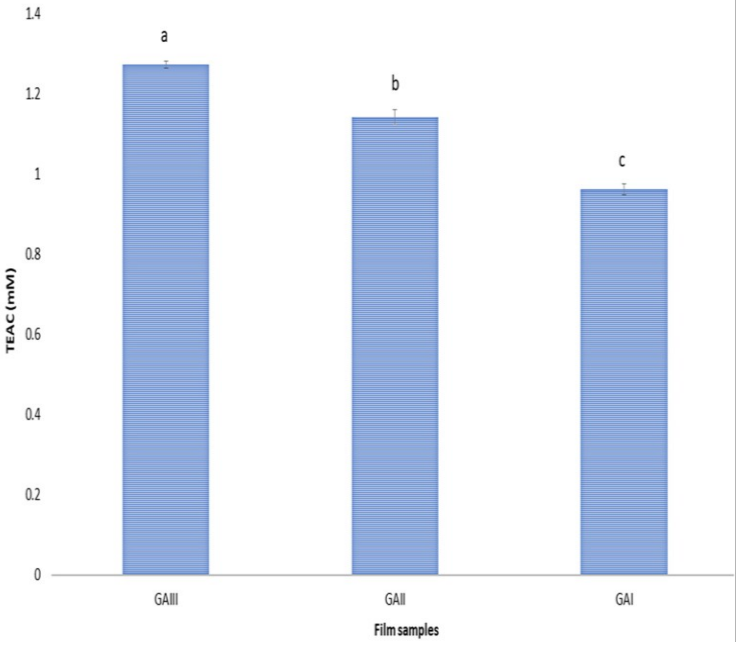
Release kinetics





Antioxidant activity





Film attivi antiossidanti

I% 45% of **SC/GA/PBS film**

Single layer

→ Riduzione del **28% di MDA** del grana padano dopo 7 giorni di conservazione a 40°C

I% 46% of **CH/SC/REO/Nylon film**

Single layer

→ Riduzione del **20% di MDA** in creme di nocciola dopo 45 giorni di conservazione a 4°C

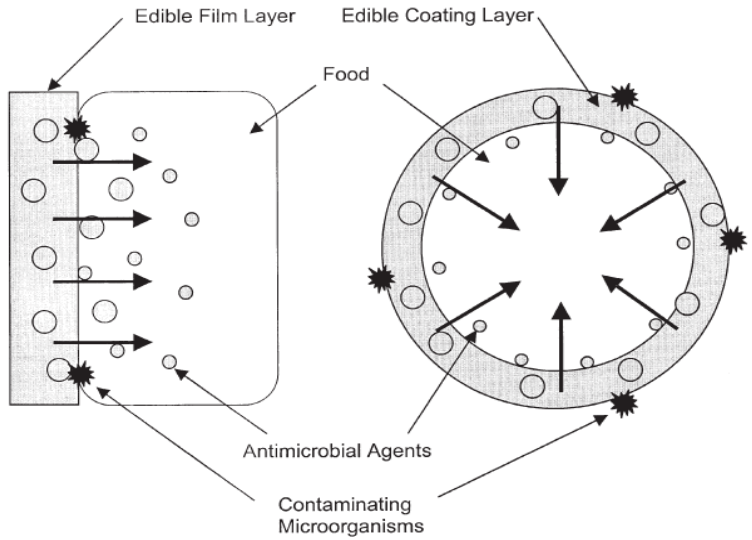
I% 80% of **CH/SC/REO film**

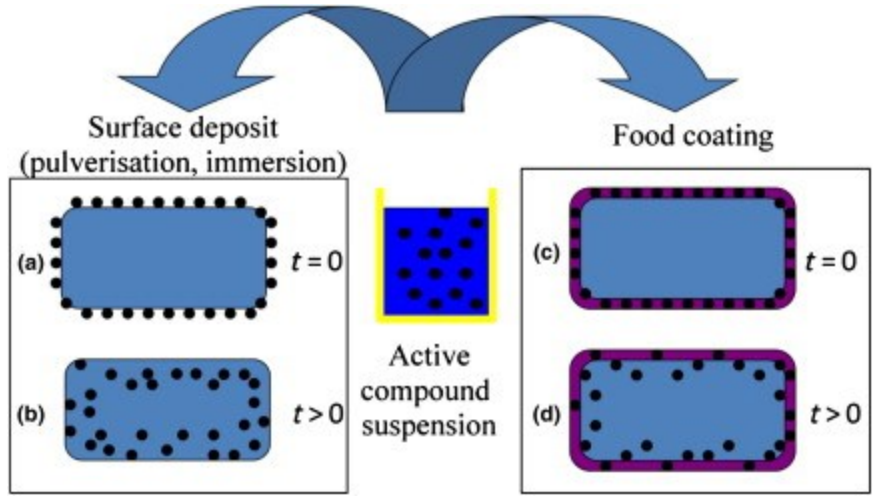
→ Riduzione del **20% di MDA di hamburger di carne dopo 11 giorni di conservazione a 4°C**

Coating *attivi* a base di biopolimeri

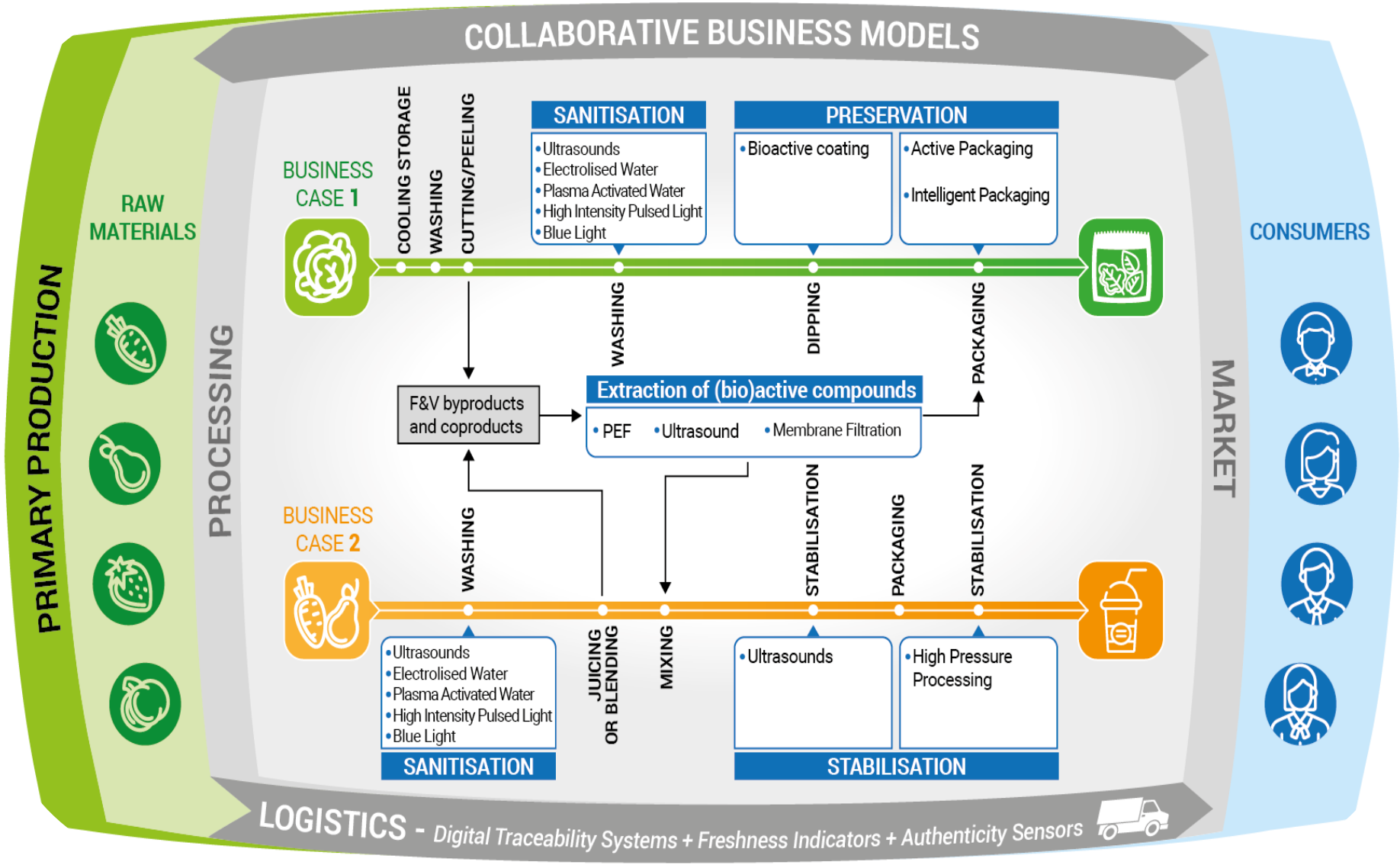
Carrier di sostanze attive:

- Antimicrobiche
- Antiossidanti





Tecnologie non termiche per preservare la qualità e sicurezza di prodotti di IV gamma

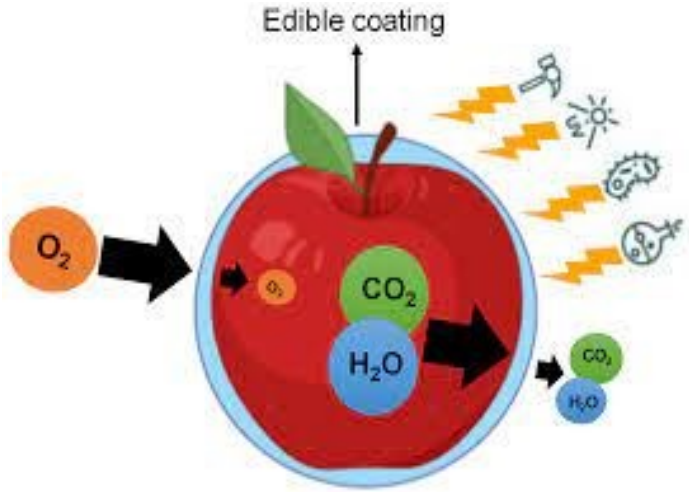


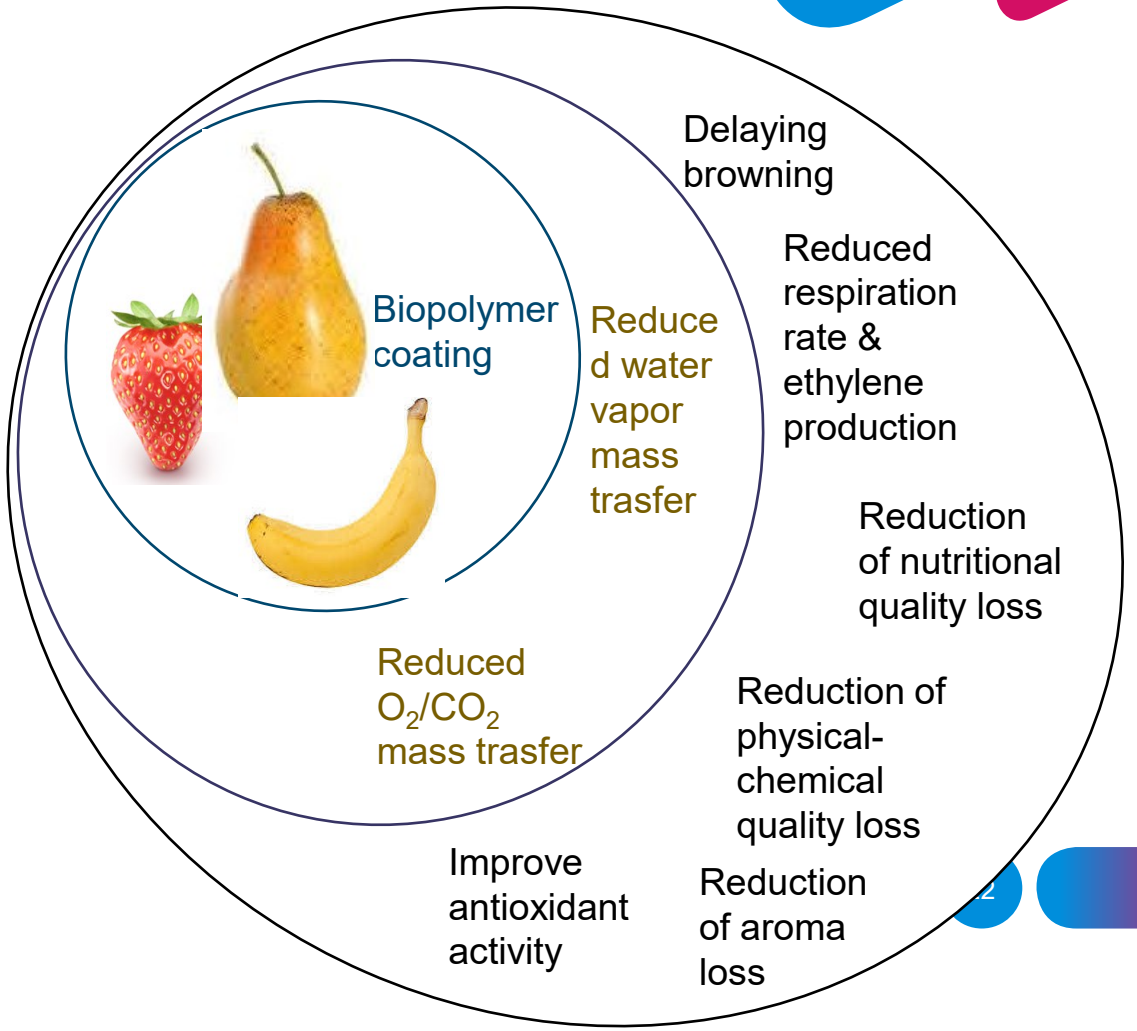
Coating attivi a base di biopolimeri per estendere la shelf life di frutta e verdure minimamente processata

Ph.D Marika Valentino

Coating *attivi* a base di biopolimeri

- Sottile strato di materiale edibile applicato sulla superfice dell'alimento





coatings

Stima dello spessore del coating

Article

Active Biopolymer Coating Based on Sodium Caseinate: Physical Characterization and Antioxidant Activity

Marika Valentino [1], Stefania Volpe [2,*], Fabio Angelo Di Giuseppe [1], Silvana Cavella [1] and Elena Torrieri [1]

$$h_{avg} = \frac{q}{A} = K\left(\frac{\eta\pi r}{\rho g t}\right)^{1/2}$$

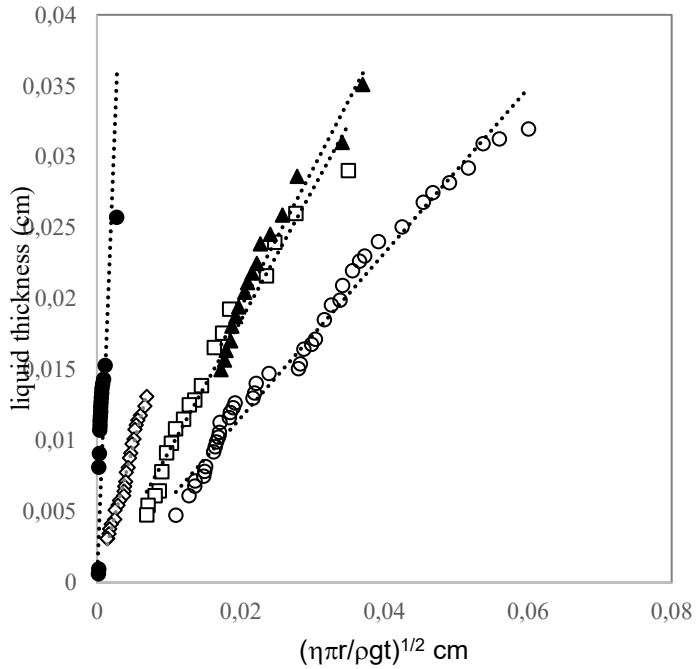
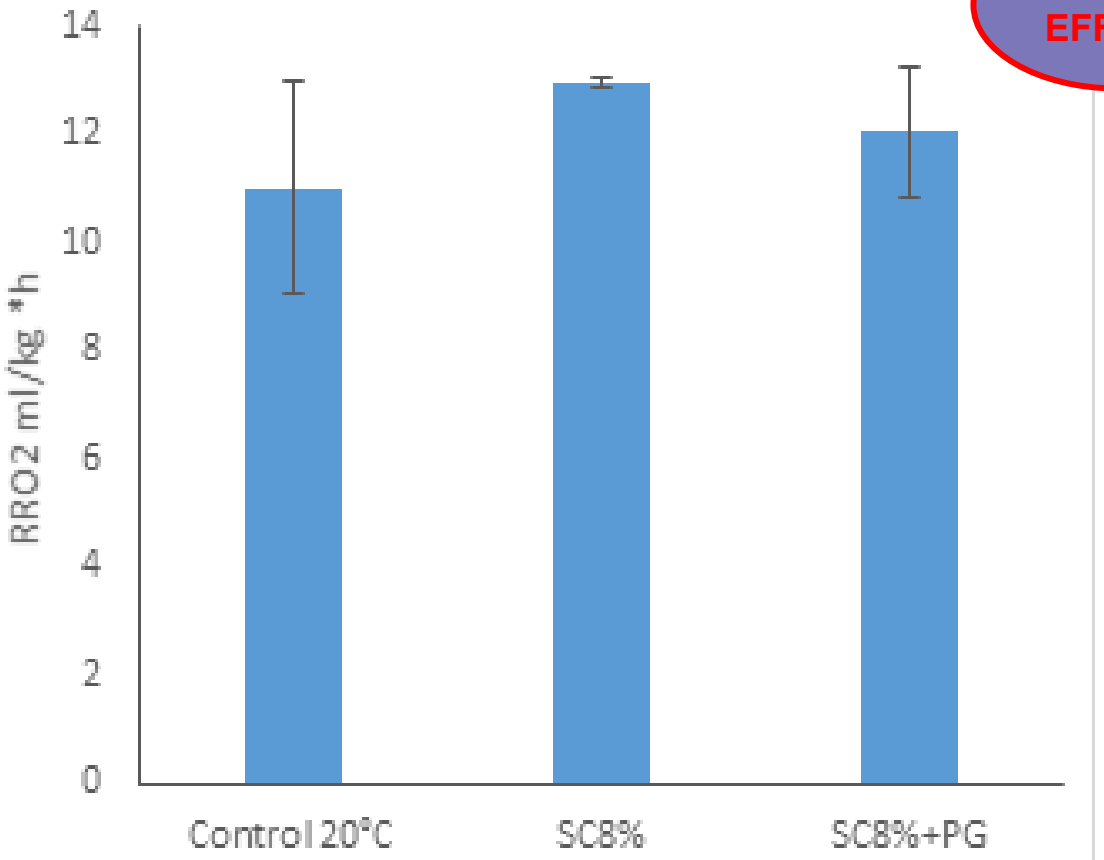
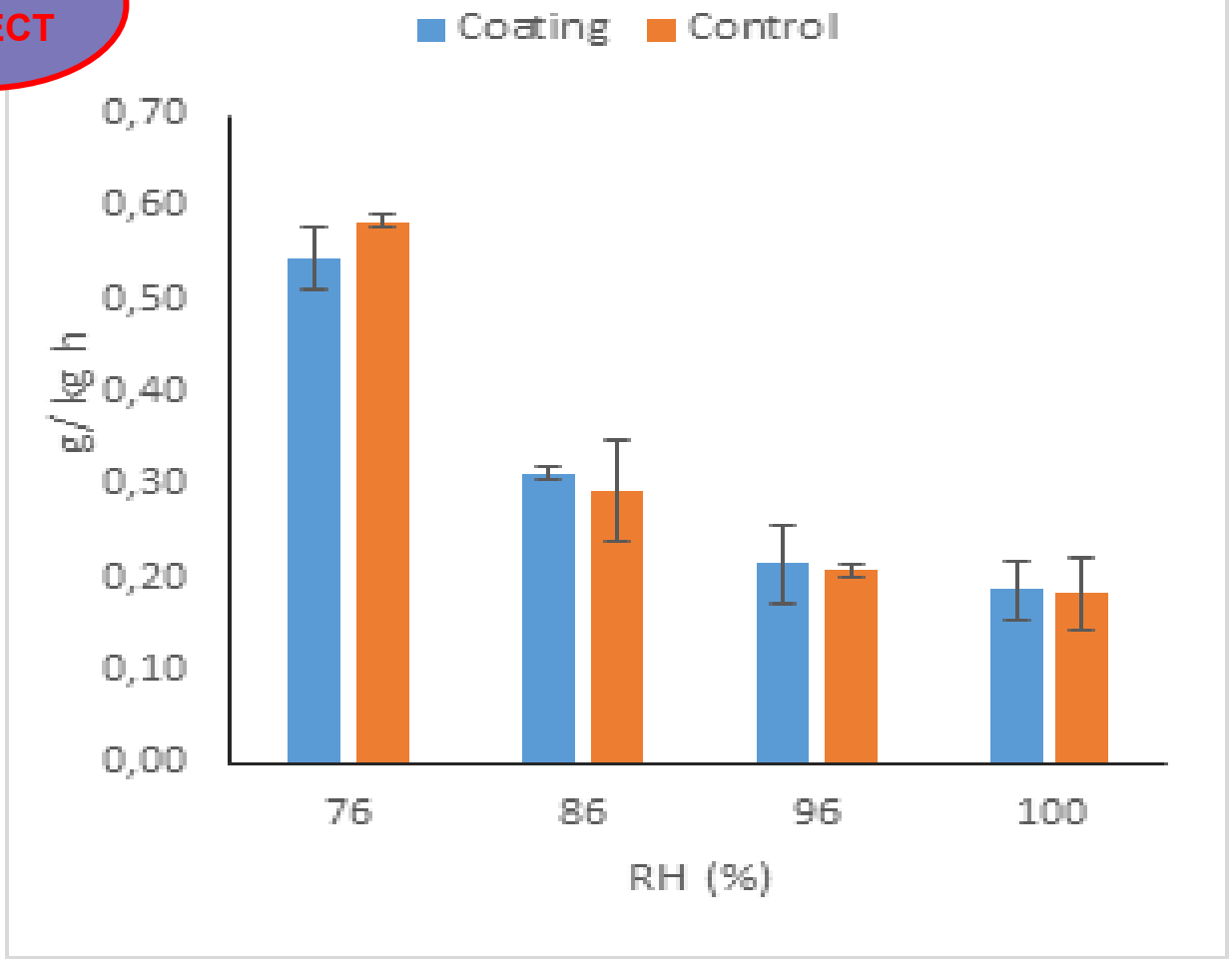


Table 3. Density of SC solutions (ρ), dimensionless K factor, average liquid film thickness on fennel (h_{avg}), density of SC film (ρ_f), and average dry coating thickness on fennel (H_{avg}) as function of SC concentration.

Sample	ρ (g·cm^{-3})	K	h_{avg} (μm)	ρ_f (g·cm^{-3})	H_{avg} (μm)
SC 4%	0.98	13	18	1.14	0.61
SC 8%	0.96	1.91	33	1.33	1.90
SC 10%	0.94	0.92	36	1.35	2.52
SC 12%	0.93	0.97	74	1.37	6.06
SC 14%	0.92	0.58	78	1.40	7.20

Respiration rate and Transpiration rate of MP Fennel





Journal of Food Engineering 331 (2022) 111123

Contents lists available at ScienceDirect

Journal of Food Engineering

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

Improving physical properties of sodium caseinate based coating with the optimal formulation: Effect on strawberries' respiration and transpiration rates

Nicoletta Antonella Miele, Stefania Volpe, Elena Torrieri *, Silvana Cavella

Obiettivo:
Ottimizzare le proprietà barriera dei coating per controllare I processi di senescenza dei frutti

Table 1
Formulations of the analyzed samples.

Samples	Composition				
	T (%)	S (%)	T:S	BW (%)	GG (%)
1 [a]	0	0	0	1	0.2
2 [a]	0	0	0	1	0.4
3 [a]	0	0	0	2	0.2
4 [a]	0	0	0	2	0.4
5 [b]	0.063	0.187	1:3	1	0.2
6 [b]	0.063	0.187	1:3	1	0.4
7 [b]	0.125	0.375	1:3	2	0.2
8 [b]	0.125	0.375	1:3	2	0.4
9 [c]	0.125	0.125	1:1	1	0.2
10 [c]	0.125	0.125	1:1	1	0.4
11 [c]	0.25	0.25	1:1	2	0.2
12 [c]	0.25	0.25	1:1	2	0.4
13 [d]	0.187	0.063	3:1	1	0.2
14 [d]	0.187	0.063	3:1	1	0.4
15 [d]	0.375	0.125	3:1	2	0.2
16 [d]	0.375	0.125	3:1	2	0.4

T: Tween 80; S: Span 80; BW: Beeswax; GG: Guar gum; *a*: no surfactant; *b*:HLB: 7; c: HLB = 9.2; d: HLB = 12.5.

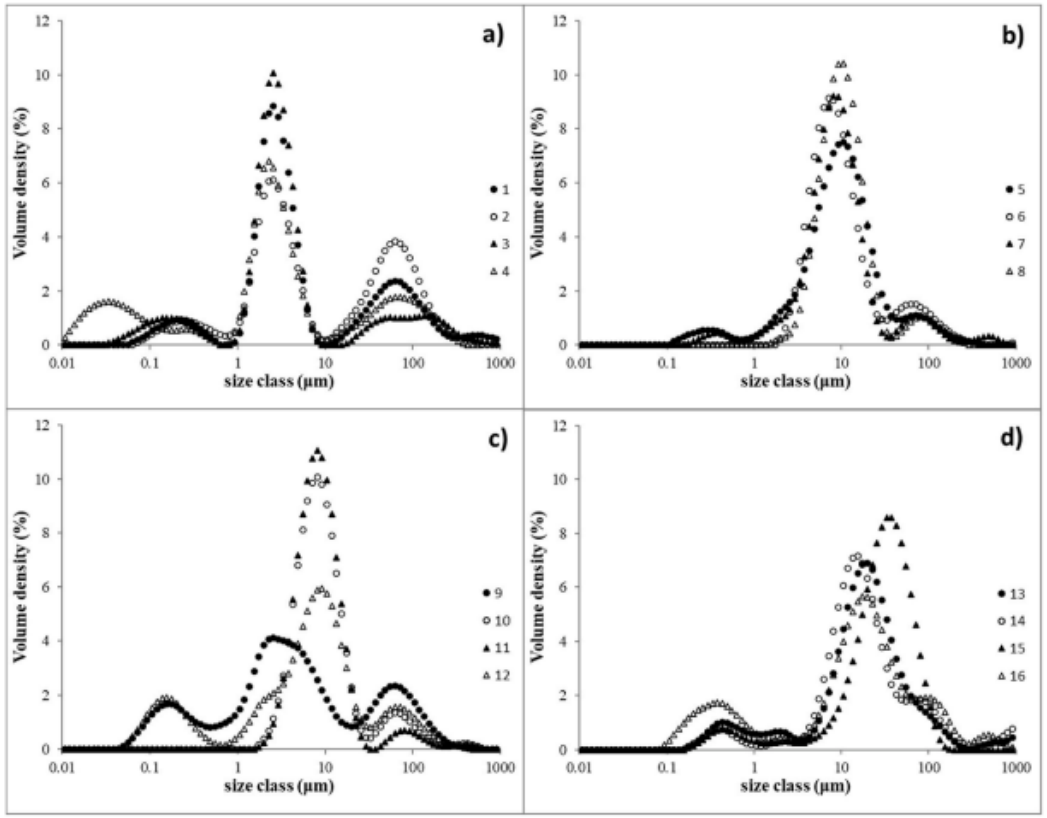


Fig. 1. Particle size distributions of 16 formulations. a) formulations 1–4, without surfactants; b) formulations, with surfactants HLB 7; c) formulations 9–12, with surfactants HLB 9.2; d) formulations 13–16, with surfactants, HLB 12.5.

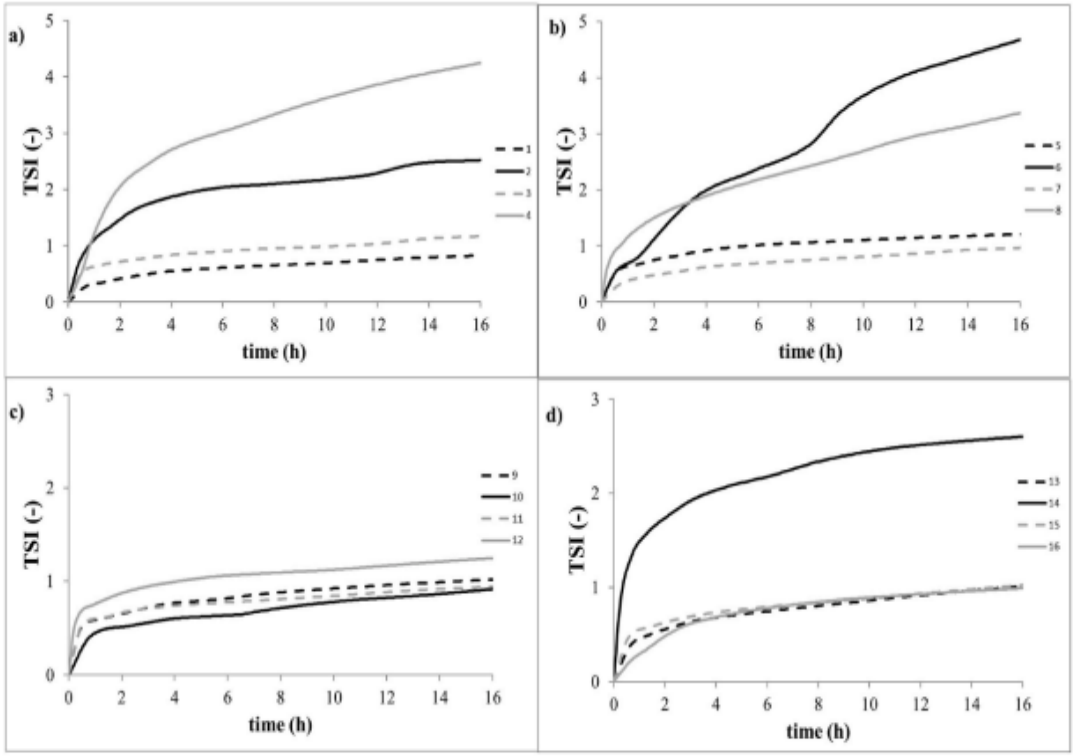


Fig. 3. Global Turbiscan stability index (TSI) vs time. a) formulations 1–4, without surfactants; b) formulations, with surfactants HLB 7; c) formulations 9–12, with surfactants HLB 9.2; d) formulations 13–16, with surfactants, HLB 12.5.

Samples with an **HLB of 9.2** were selected for their physical stability and their optimal PSD properties (narrow and small particle size distribution of the fat phase).

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Table 4
Colorimetric parameters (L*, a*, b*, ΔE), thickness, moisture content (MC) and water vapor barrier properties of films obtained from samples 9, 10, 11 and 12.

Samples	L*	a*	b*	ΔE	Thickness (mm)	*MC %	WVTR (g m^{-2} day^{-1})	WVP ($x10^{-11}$) (g m^{-1} sec^{-1} Pa^{-1})
9	95.6 ± 0.3^{b}	0.83 ± 0.03^{d}	5.6 ± 0.2^{a}	4.2 ± 0.9	0.036 ± 0.005^{a}	8.7	166 ± 14^{b}	7.0 ± 0.3^{c}
10	95.1 ± 0.2^{a}	1.15 ± 0.07^{c}	6.7 ± 0.1^{b}	5.4 ± 0.6	0.076 ± 0.005^{b}	8.4	59 ± 17^{a}	2.7 ± 0.7^{a}
11	95.2 ± 0.5^{ab}	1.43 ± 0.07^{b}	8.2 ± 0.2^{c}	7 ± 1	0.068 ± 0.005^{c}	7	75 ± 17^{a}	3.4 ± 0.9^{ab}
12	95.61 ± 0.06^{b}	1.88 ± 0.01^{a}	8.9 ± 0.1^{d}	7.5 ± 0.7	0.081 ± 0.005^{d}	7	86 ± 15^{a}	4.1 ± 0.6^{b}

* Measured after equilibrium at 50% of relative humidity.

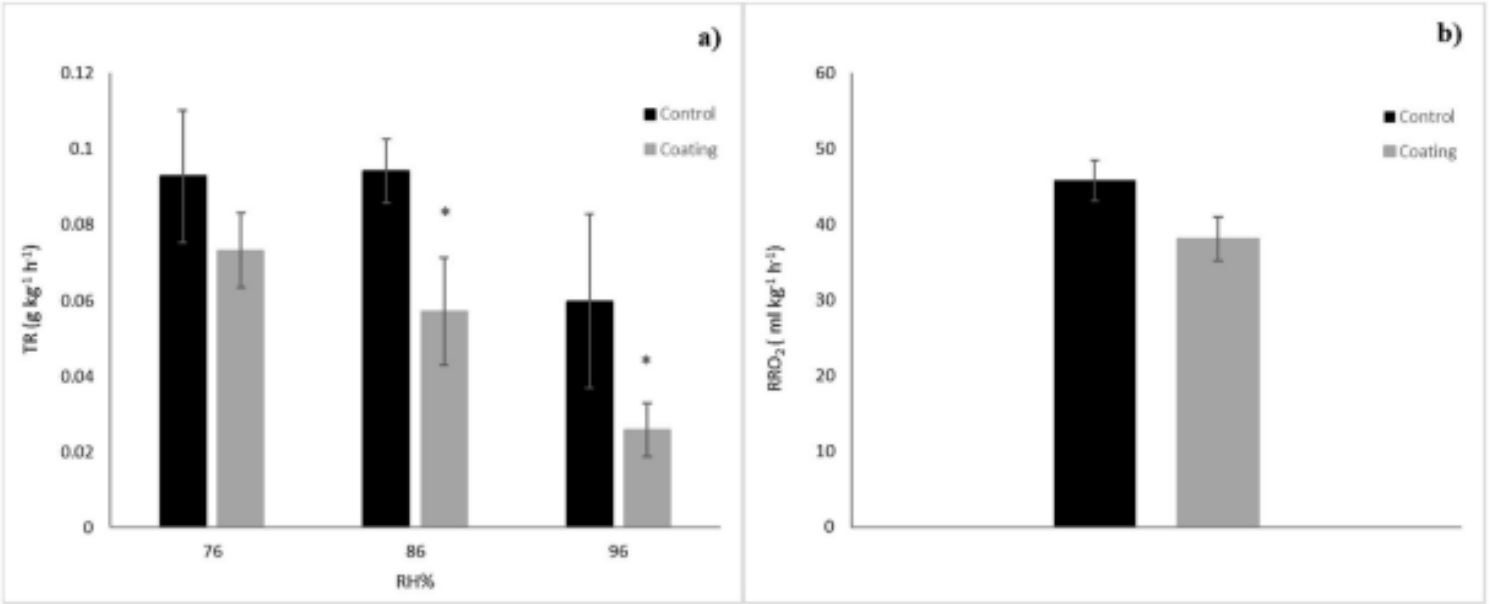
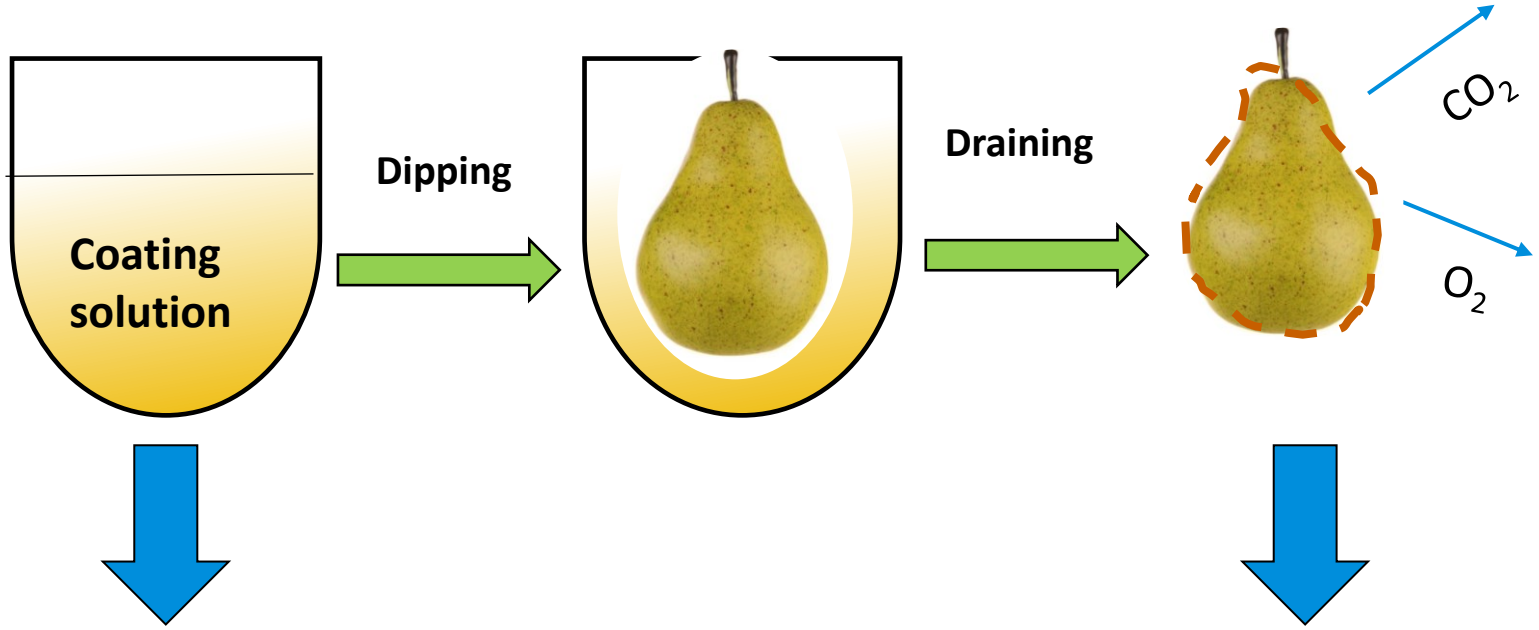


Fig. 5. Transpiration rate of coated and control strawberries expressed in g kg^{-1} h^{-1} at 4 °C and 75%, 86% and 96% RH (a). Respiration rate of coated and control strawberries expressed as RRO_2 (ml kg^{-1} h^{-1}) calculated at 4 °C (b).

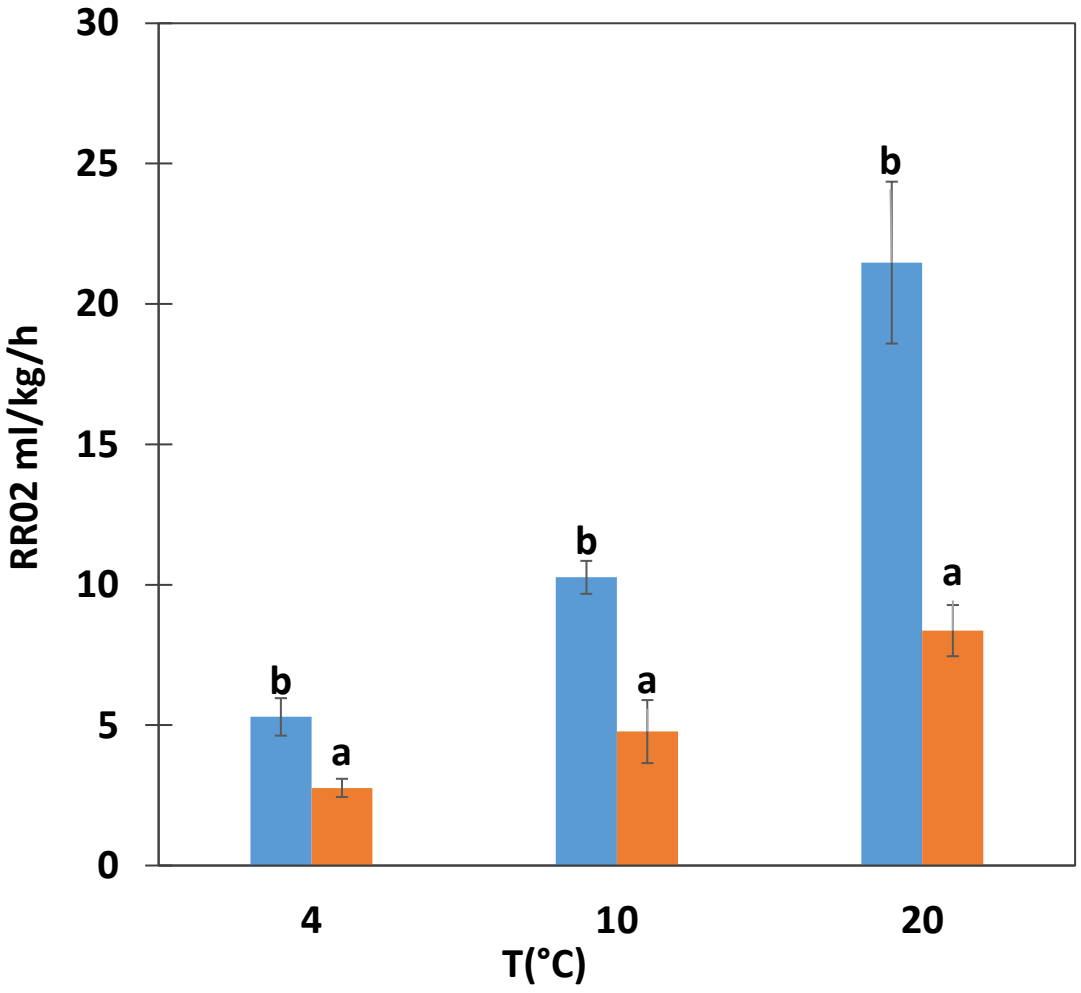
The average liquid thickness (havg) and the dry coating thickness estimated on strawberries (Havg) were found to be 63 ± 8 µm and 4,5 ± 0.6 µm, respectively.

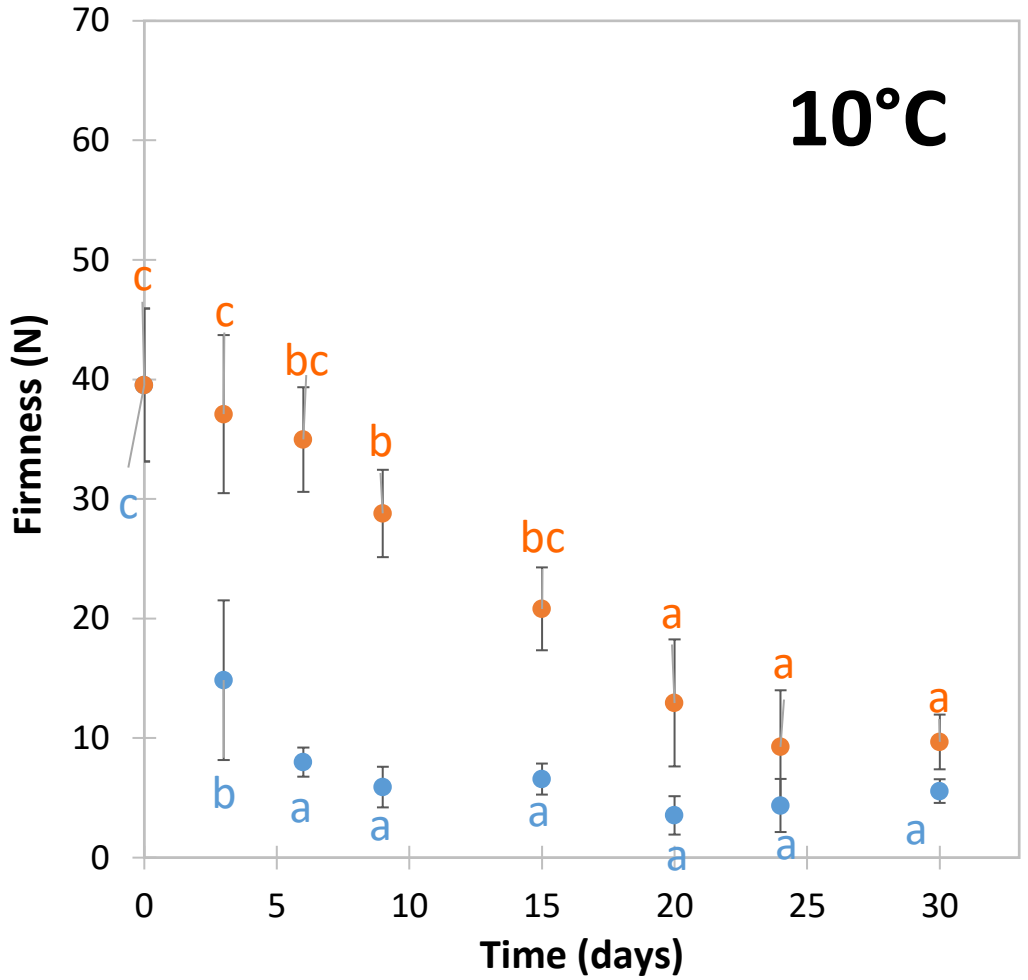
Coating attivi antiossidanti



- Sodium caseinate
- Guar gum
- Beeswax
- Tween 80-Span 80
- Propyl gallate

Shelf life extimation at 20°C and 10°C at RH 70%





pears control (•) and with coating (•)

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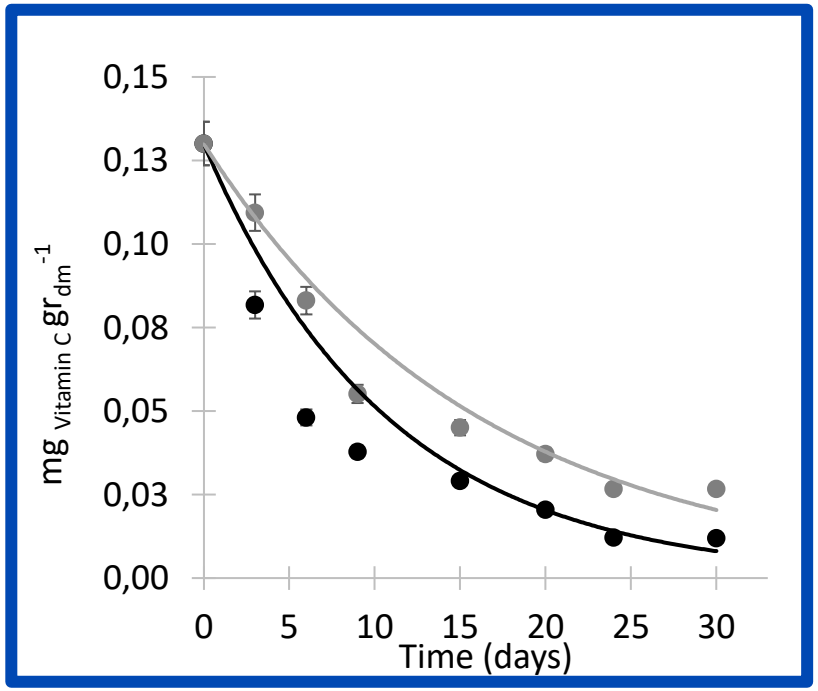
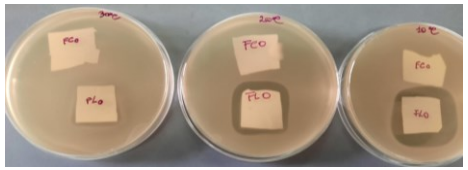
T (°C)	Samples	Firmness	Total antioxidant capacity	Total polyphenols content	Vitamin C content
		k (Day^{-1})			
10	Control	0.291±0.034^{b}	0.081±0.022^{b}	0.035±0.005^{b}	0.115±0.005^{b}
	Active	0.044±0.005^{a}	0.016±0.043^{a}	0.016±0.004^{a}	0.068±0.003^{a}
20	Control	0.626±0.049^{b}	0.078±0.008^{b}	0.149±0.004^{b}	0.523±0.064^{b}
	Active	0.031±0.008^{a}	0.062±0.001^{a}	0.077±0.006^{a}	0.129±0.002^{a}



Time of 60% reduction (days)				
Nutritional properties	10°C		20°C	
	Control	Active	Control	Active
Antioxidant (mg TROLOX/g dm)	6	30	6	15
Polyphenol (mg GAE/g dm)	15	-	7	15
Vit C (mg/g)	6	15	1	3

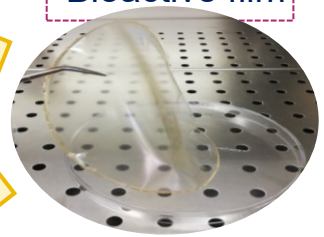
Coating attivi antimicrobici

Sodium caseinate +Guar gum + Beewax +m-MRS broth + **Lactobacillus curvatus 54M16**

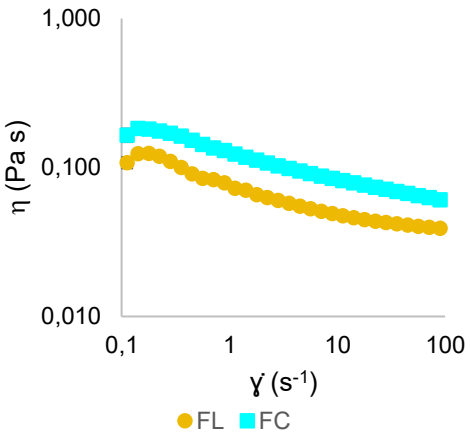


Antilisterial activity

Bioactive film

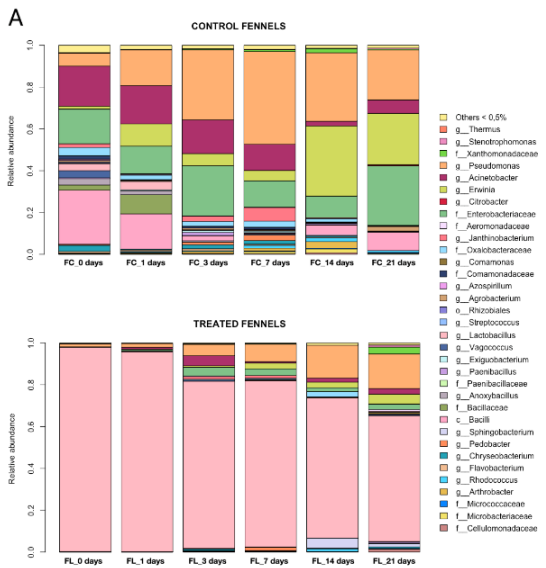


Bioactive coating



Sample	Tensile properties			WVP x 10^{11}	Δx
	EM (Mpa)	TS (Mpa)	ε%	(g m^{-1} s^{-1} Pa^{-1})	(mm)
FC	222±30 ^{b}	5±1 ^{b}	4±1 ^{a}	4.8±0.5^{a}	0.09±0.01^{a}
FL	184±31 ^{a}	3.7±0.8 ^{a}	4±1 ^{a}	5.8±0.7^{b}	0.10±0.02 ^{b}

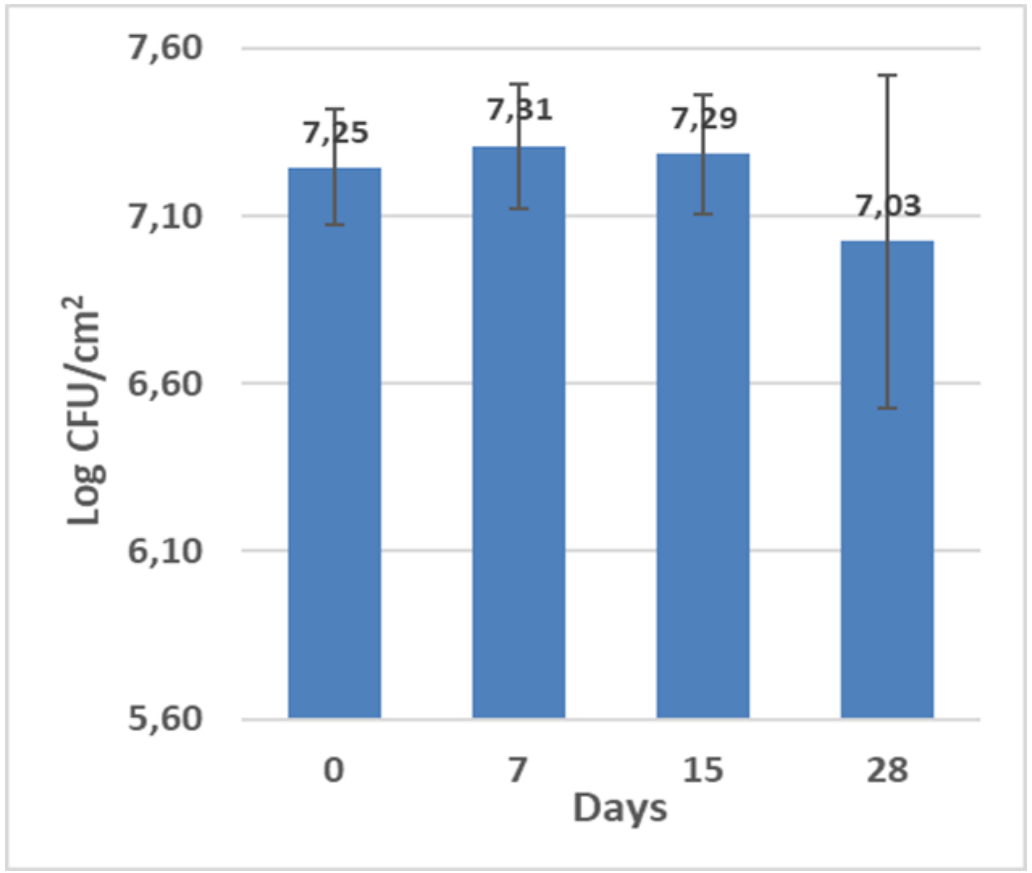
Tensile properties, WVP and thickness



Microbiota composition on fennel during storage

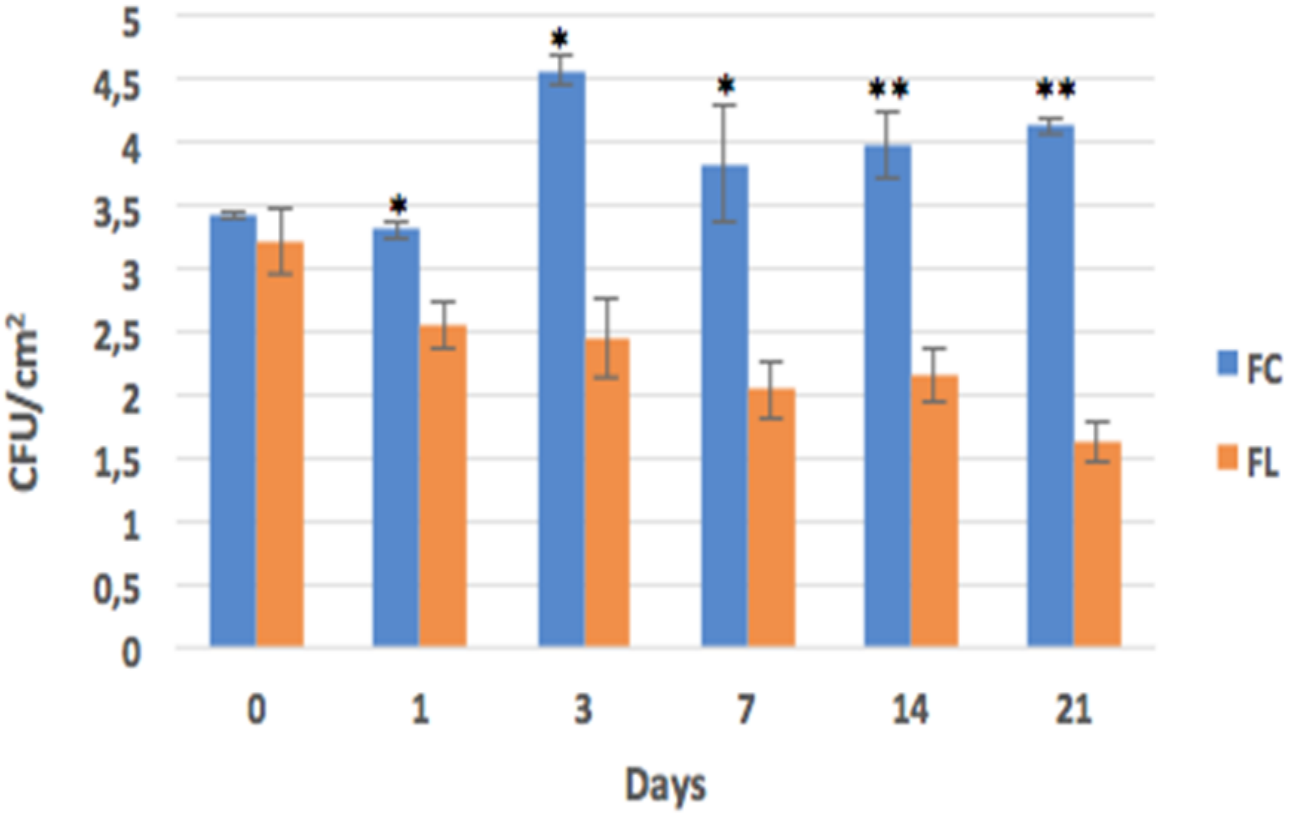
Listeria innocua

Antimicrobial activity on fennels during storage



Vitalità di Lb. curvatus 54M16 in film a base di caseinato durante la conservazione a 4°C.

Listeria spp. count



Coating +Lb. curvatus 54M16 applicati a finocchi MP

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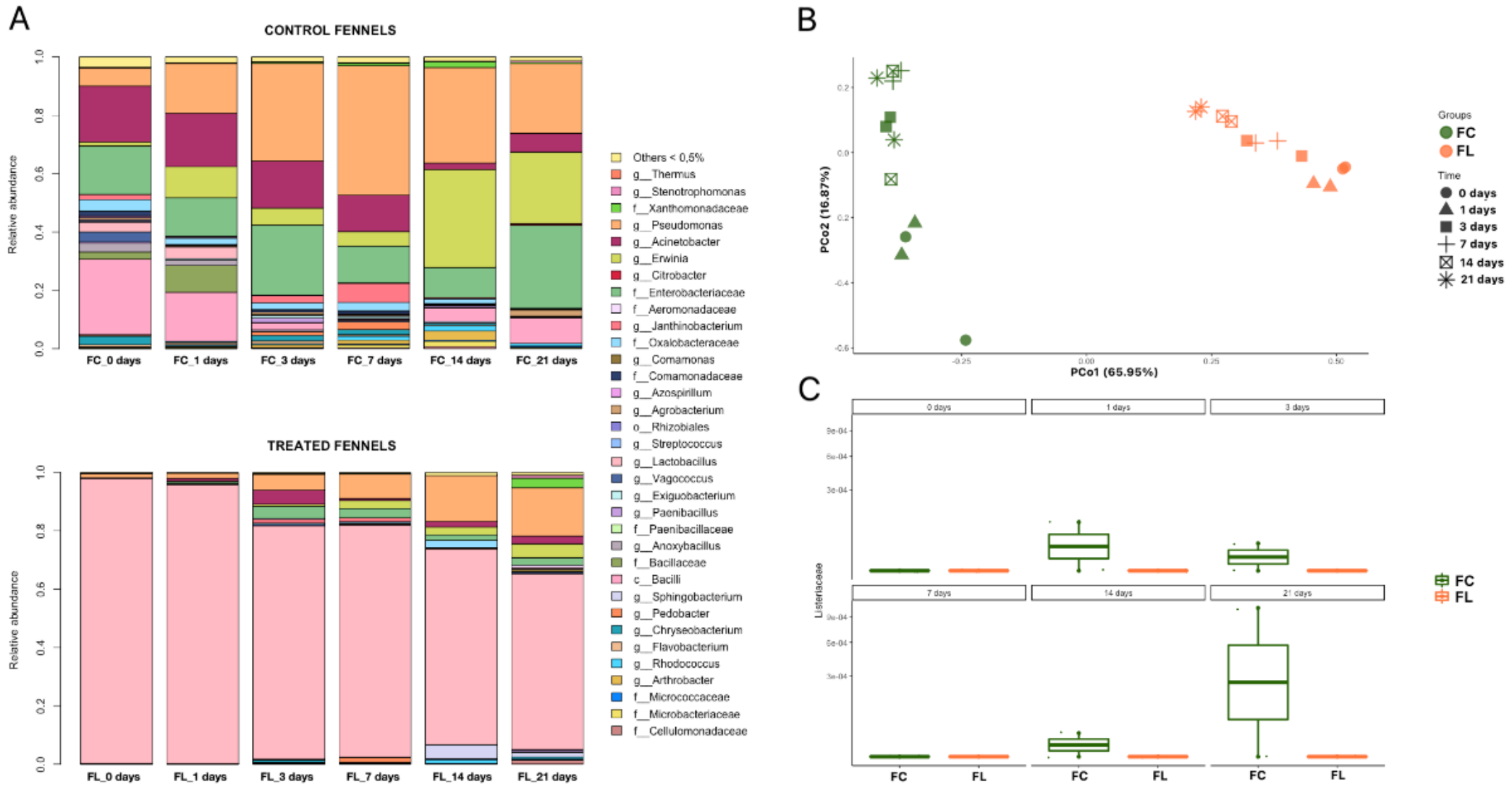

The addition of L. curvatus 54M16 strongly changed the overall microbiota composition:

- *Aeromonadaceae*, *Enterobacteriaceae*, *Pseudomonas,* and *Acinetobacter* as dominant taxa in fennel
- Microbial diversity dramatically decreased in samples coated with antimicrobial film, that was dominated by *Lactobacillus* sp.

Prospettive future: Agritech

Agritech: National Research Centre for Agricultural Technologies

Spoke Leader: Università degli Studi di Milano

8 - Circular economy in agriculture through waste valorization and recycling

WP	**8.1** Producing new products to upgrade waste value	**8.2** Agroenergy production from wastes to reduce energy dependence	**8.3** Nutrient and organic matter recovery from wastes to reduce the use of agrochemicals and closing waste cycle	**8.4** Sustainability assessment of the technologies and their integration in agriculture
GOAL	Obtain from organic wastes high-value products with biological properties and technological potential	Promote sustainable agroenergy production by waste valorization through biological and thermochemical approaches, not affecting feed/food production	Produce biofertilizers to support soil fertility and mitigate climate change	Develop a holistic approach to promote sustainability, circularity and integration with agricultural systems

Prospettive future: Agritech

SPOKE 8: Circular economy in agriculture througth waste valorization and recycling

- **WP8.1. – Producing new products to upgrade waste value – Partner Leader: UNIMI**

Task	Deliverable	Involved Partners
T8.1.1 Valorisation of the waste by green chemistry to obtain for high value molecules or new products	D8.1.1 Pilots and prototypes to obtain new products from wastes (M30) D8.1.2 Products obtained and their characterisation (M33)	UNIMI, POLIMI, UNISA, ENEA, UNIPR, UNINA, UNIBO, CNR, POLITO, ENI
T8.1.2 Valorisation of the waste by biotechnology processes to obtain for high value molecules or new products		UNIMI, UNIPR, UNINA, UNIBO, CNR, POLITO, ENI
T8.1.3 Valorisation of the waste to obtain biomaterials		UNIMI, POLIMI, UNISA, ENEA, UNINA, UNIBO, CNR, IRR

Milestones: M8.1.1 Preliminary assessment of the products obtained (M12); M8.1.2 Design of technologies, bio-technologies and infrastructures (M24)

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Per approfondimenti

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SCUOLA DI AGRARIA E MEDICINA VETERINARIA 2023

IL caffè SCIENTIFICO

Grazie per l'attenzione

Nuovi sistemi di frollatura, maturazione e stagionatura delle carni: opportunità e possibili rischi

Raffaele Marrone

10 Maggio, 2023

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