" Increasing packaging performance to assure food quality and safety: Recent research topics developed @ UNIBO - CIRI AGRIFOOD "

MARCO DALLA ROSA

Interdepartmental Centre for Agri-Food Industrial Research
Alma Mater Studiorum - Università di Bologna

POR FESR EMILIA-ROMAGNA 2014/2020
POR FSE 2014-2020 ER Educazione Ricerca Emilia-Romagna
UNIONE EUROPEA Fondi strutturali e di investimento europei
RegioneEmilia-Romagna

BOLOGNA UNIVERSITY

https://youtu.be/KEPqwXgvcCw

1088

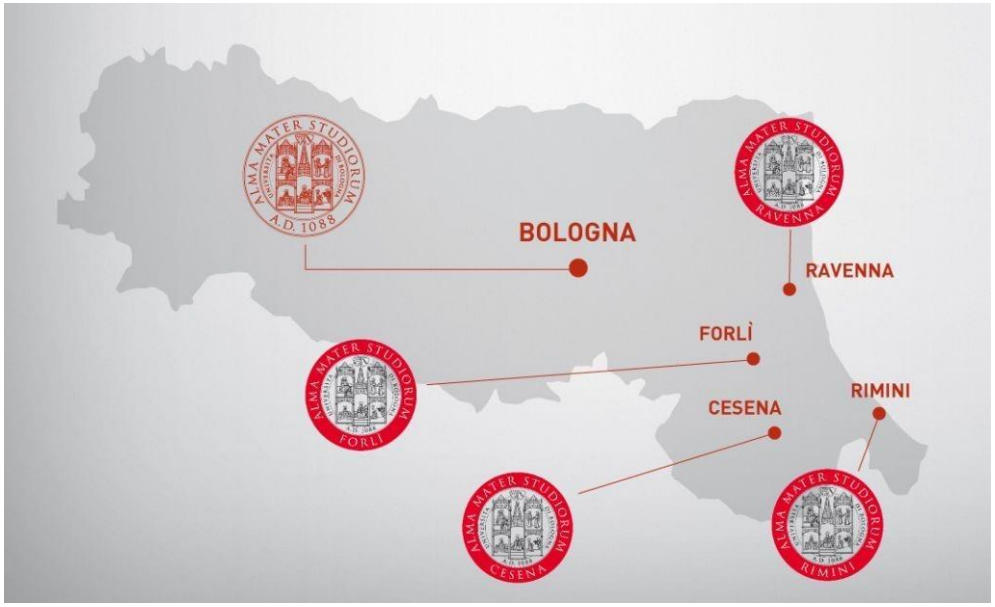
Cortile d'Ercole, Palazzo Poggi, Photo: S. Mirabella

CONSTITUENT PRINCIPLES

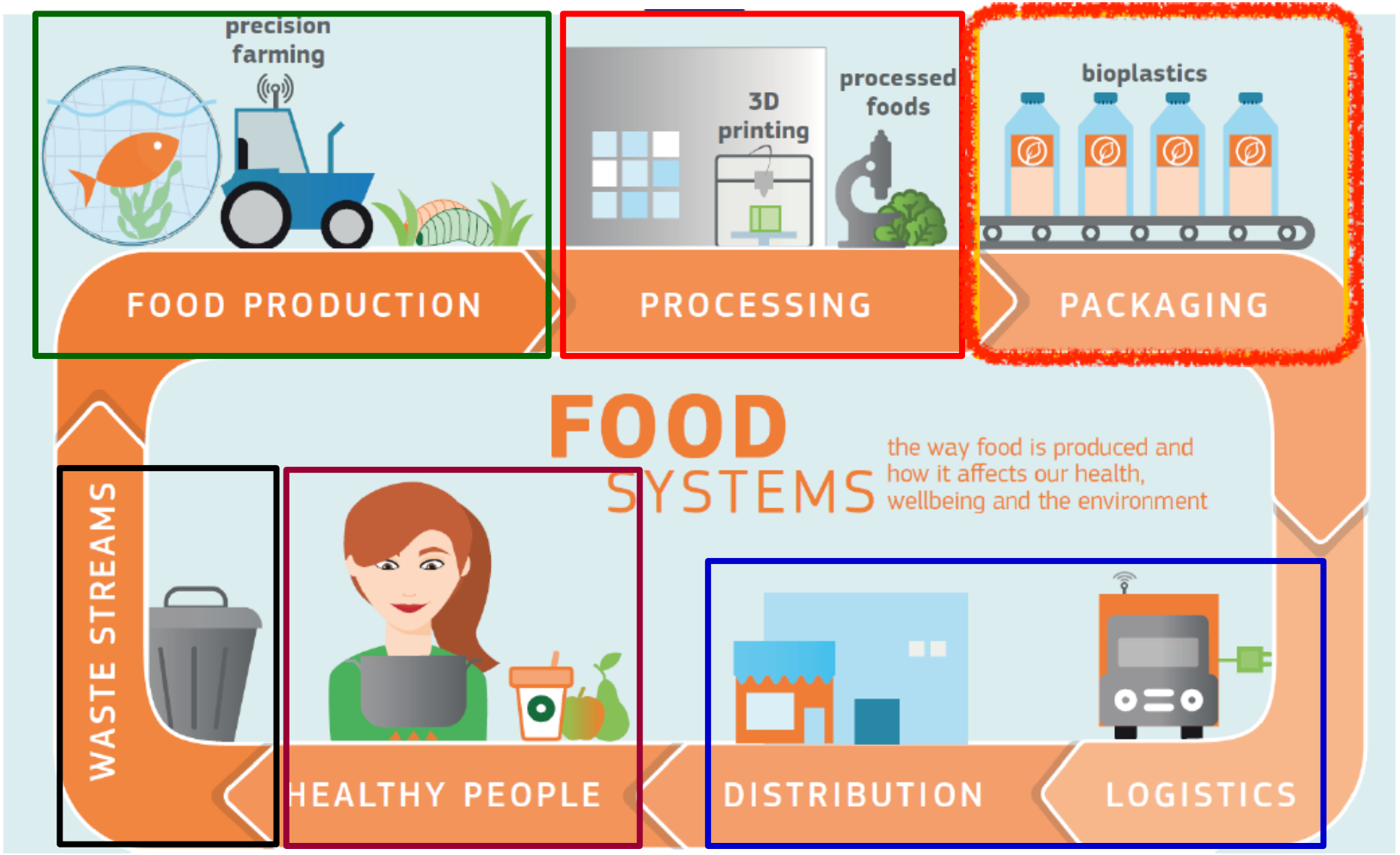
Alma Mater Studiorum – University of Bologna is a multi-campus university

Based in Bologna, Cesena, Forlì, Ravenna, and Rimini

Buenos Aires



Main R&I priorities for the agrifood sector



Food packaging innovation and optimization @UNIBO – CIRI AGRO

- shelf-life prolongation of minimally processed foods, RTE and dried ingredients, SL / ASLT studies
- MAP, food / packaging interaction
- introduction of biopolymers
- active packaging to improve antimicrobial, antioxidants properties
- intelligent / smart packaging to improve traceability and product informations

MAP - Minimally processed fruit

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Available online at www.sciencedirect.com
SCIENCE DIRECT®

Postharvest Biology and Technology 35 (2005) 319–328

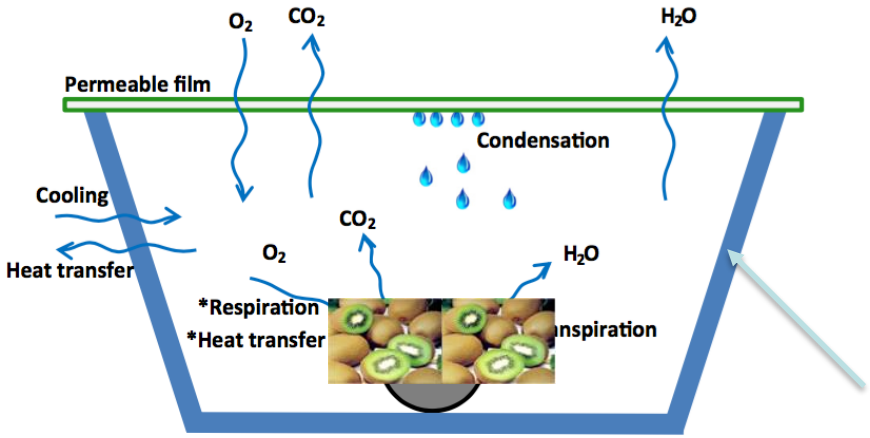
Postharvest Biology and Technology

www.elsevier.com/locate/postharvbio

Effect of MAP with argon and nitrous oxide on quality maintenance of minimally processed kiwifruit

Pietro Rocculi*, Santina Romani, Marco Dalla Rosa

Specifications for processing and targeted uses of food packaging responding to the specific requirements of fresh produce, the most promising market niche for biodegradable packaging



Low heat transfer

Medium - high mechanical resistance

Respiring foods

Modelling O_2 and CO_2 evolution in MAP

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Journal of Food Engineering 76 (2006) 334–340

JOURNAL OF FOOD ENGINEERING

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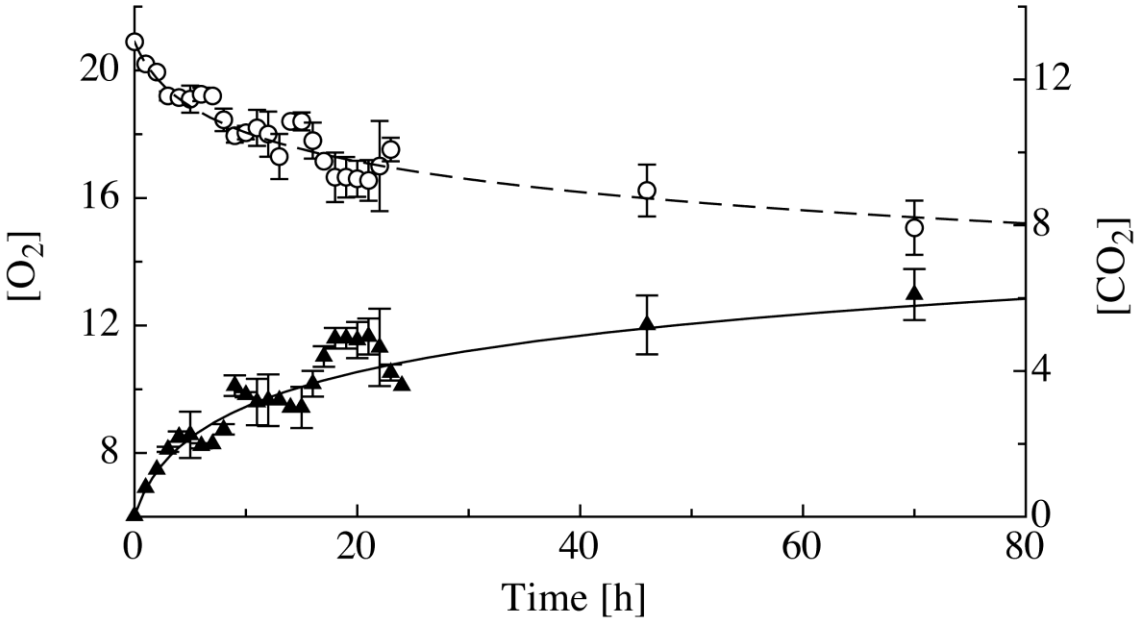
Use of a simple mathematical model to evaluate dipping and MAP effects on aerobic respiration of minimally processed apples

P. Rocculi [a,*], M.A. Del Nobile [b], S. Romani [a], A. Baiano [b], M. Dalla Rosa [a]

[a] Department of Food Science, University of Bologna, Seat of Cesena, Via Ravennate 1020, 47023 Cesena, Italy
[b] Department of Food Science, University of Foggia, Via Napoli 25, 71100 Foggia, Italy



ASSESSMENT OF TISSUE PHYSIOLOGY

Respiration

Enzymatic activity

-polyphenoloxidase

-peroxidase

-clorophyllase

-pectinesterase

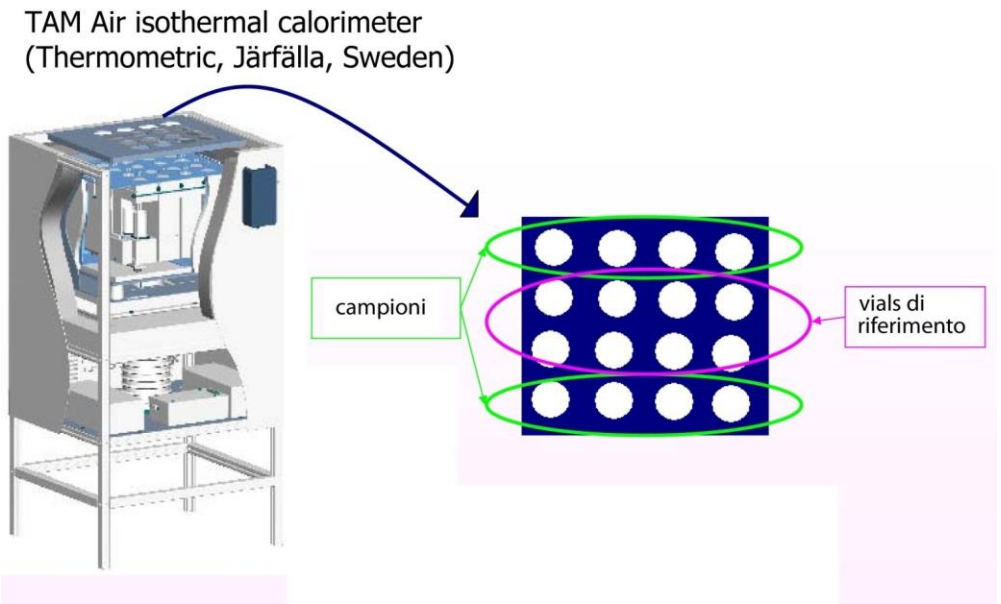
-polygalactunorase

O_2, CO_2 DETERMINATION IN HEAD SPACE OR PACKAGING

TISSUE PHYSIOLOGY (2)

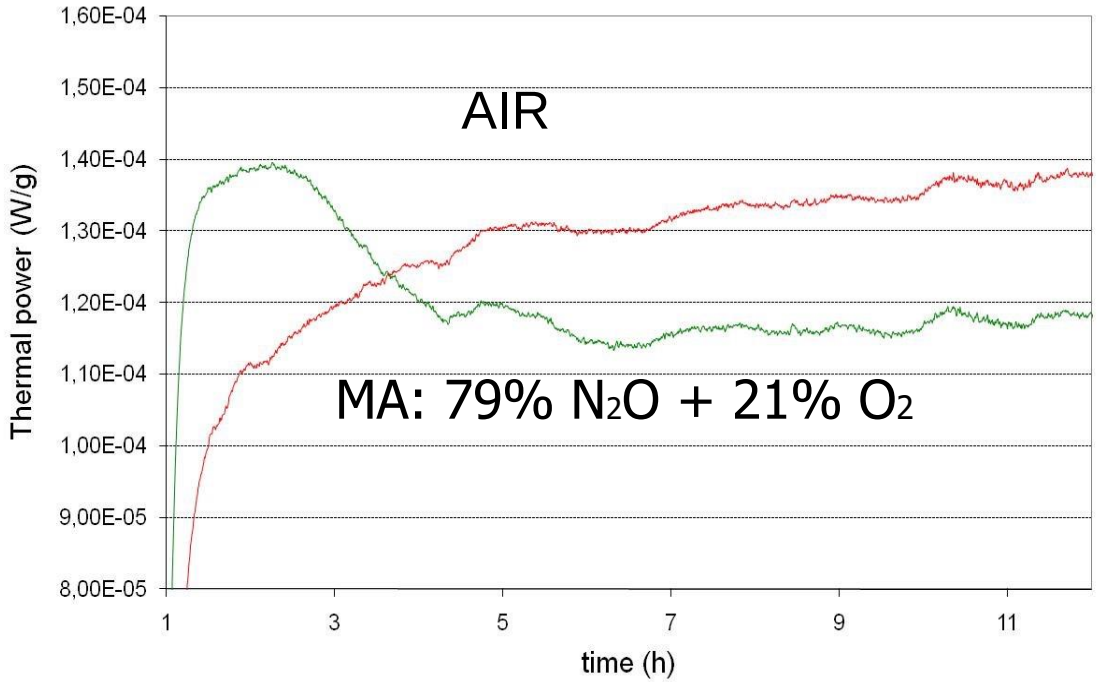
Metabolic heat

TAM-Air isothermal calorimeter



Coupled with..→

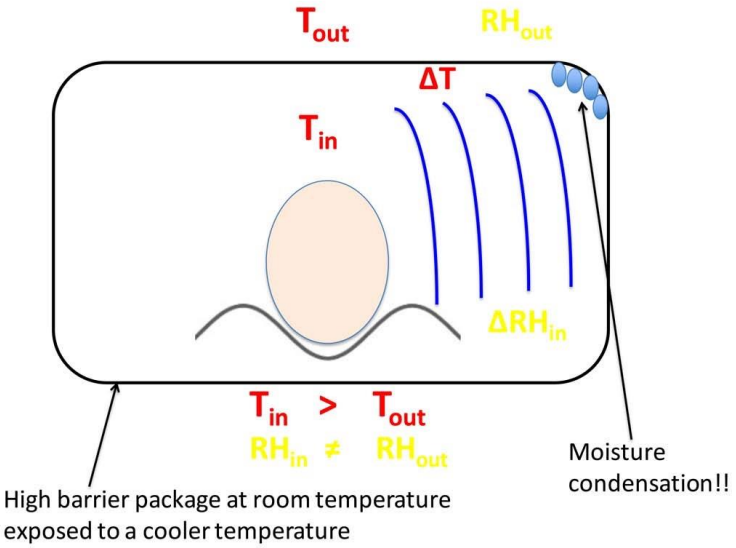
Lower metabolic heat production during the 12 h of the experiment, confirming the N_2O inhibitory effect

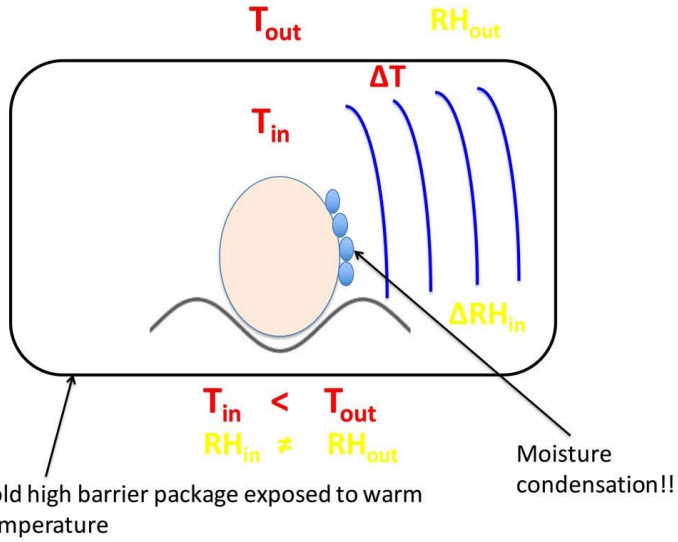


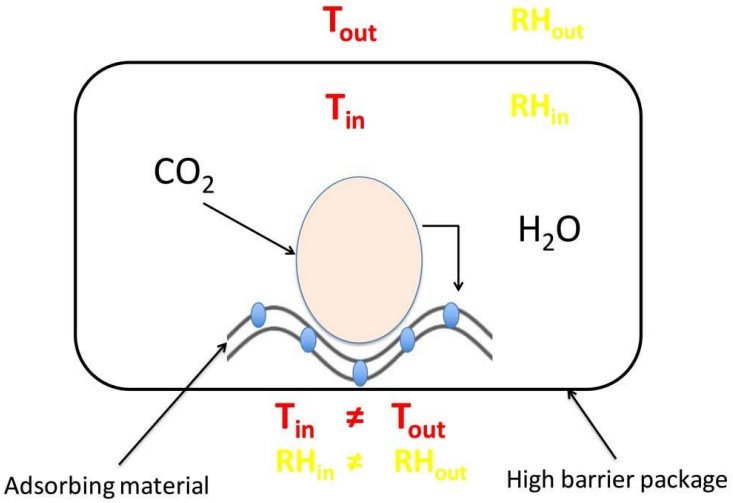
This was confirmed by the O2 and CO2 levels detected on the sample-ampoule head space at the end of the experiment:

- Air: 19.1% O2, 1.2% CO2;
- MA: 20.2% O2, 0.5% CO2

Innovative active packaging for shell-eggs







Real product

Innovative active packaging for shell-eggs

Effect on albumen technological properties

- Increase of foam stability and meringues crispness

- Modulation of coagulated albumen characteristics

Modified atmosphere packaging of hen table eggs: Effects on functional properties of albumen

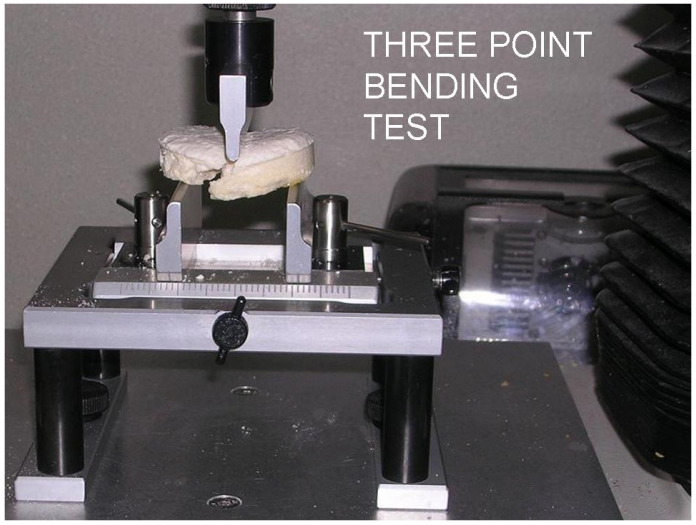
P. Rocculi,* E. Cocci,* F. Sirri,*[1] C. Cevoli,† S. Romani,* and M. Dalla Rosa*

*Department of Food Science, and †Department of Agricultural Economy and Engineering, Alma Mater Studiorum–University of Bologna, 47521 Cesena (FC), Italy

Poultry Science, vol. 90, 1791-1798

Innovative active packaging for shell-eggs

Effect on albumen technological properties



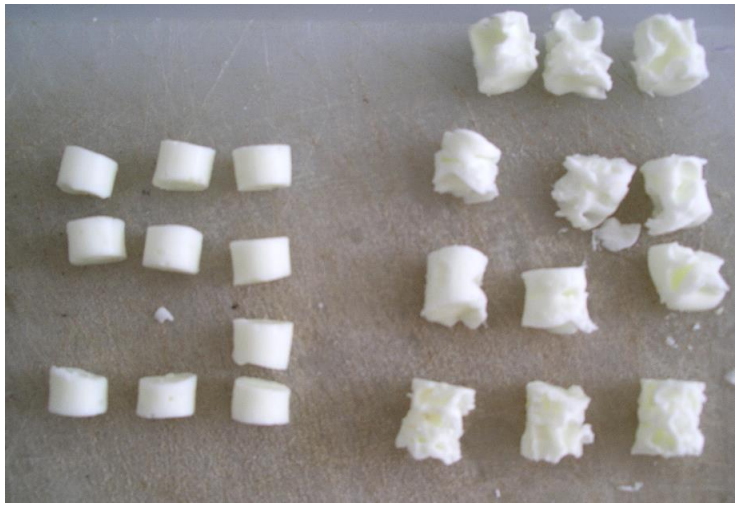
- Improved foam stability and meringue crispness

Innovative active packaging for shell-eggs

Effect on albumen technological properties

- Modulation of quality characteristics of coagulated albumen

Control Packed in CO_2



Control Packed in CO_2

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Role of innovations and emerging tehcnologies in societal challenges

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Trends in Food Science & Technology 19 (2008) 634–643

TRENDS IN FOOD SCIENCE & TECHNOLOGY

Review

Biodegradable polymers for food packaging: a review

Valentina Siracusa[a,*], Pietro Rocculi[b], Santina Romani[b] and Marco Dalla Rosa[b]

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[b]Department of Food Science, Alma Mater Studiorum, University of Bologna, Cesena (FC), Piazza Goidanich 60, c.a.p. 47023, Italy

(PE), polypropylene (PP), polystyrene (PS) and polyamide (PA) have been increasingly used as packaging materials because their large availability at relatively low cost and because their good mechanical performance such as tensile and tear strength, good barrier to oxygen, carbon dioxide, anhydride and aroma compound, heat sealability, and so on. But nowadays their use has to be restricted because they are not non-totally recyclable and/or biodegradable so they pose serious ecological problems (www.european-bioplastics.org; Sorrentino, Gorrasi, & Vittoria, 2007). Plastic packaging materials are also often contaminated by foodstuff and biological substance, so recycling these material is impracticable and most of the times economically not convenient. As a consequence several thousands of tons of goods, made on plastic materials, are landfilled, increasing every year the problem of municipal waste disposal (Kirwan & Strawbridge, 2003). The growing environmental awareness imposes to packaging films and process both user-friendly and eco-friendly attributes. As a consequence biodegradability is not only a functional requirement but also an important environmental attribute.

Shelf life studies

Real conditions

ASLT (Accelerated Shelf Life Test)

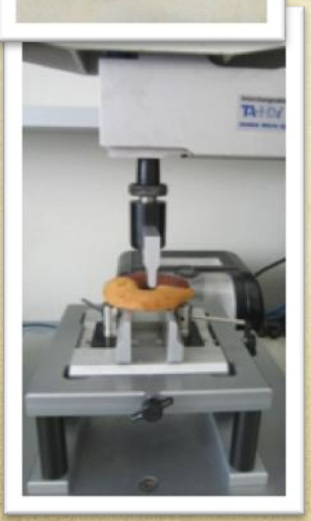
(Constant Climate Chambers – Peltier technology)

Baked products (Cookies)

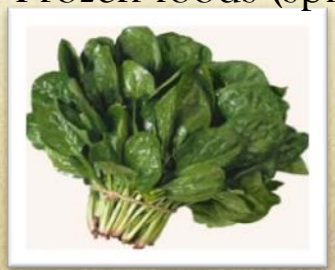
TEPASS project - Technologies for a Safe and Sustainable Agri-food

I and IV range fruit products

Shel-life evaluation of food packed in biodegradable packaging system



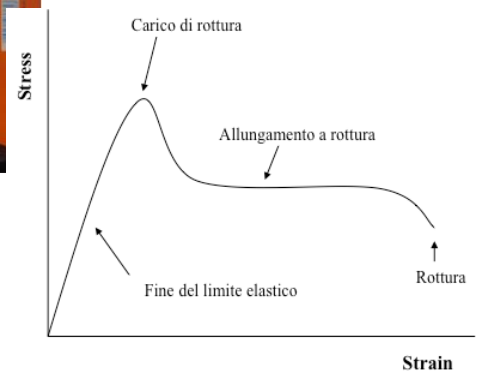
Frozen foods (spinach, cauliflower)

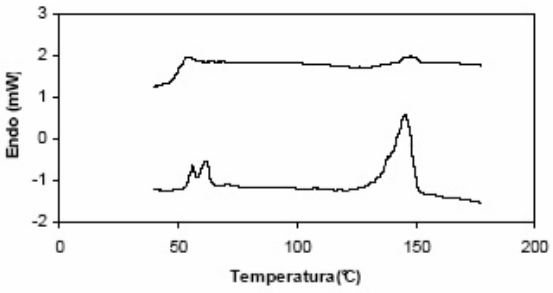


Chemical-physical characterization of biodegradable plastic films compared to traditional materials

Mechanical and thermal characterization, thickness measurements, gas permeability, FTIR spectroscopic analysis

- **in-depth information concerning the performances of the films and their use for the packaging of different foods in different storage conditions**





Effect of different new packaging materials on biscuit quality during accelerated storage

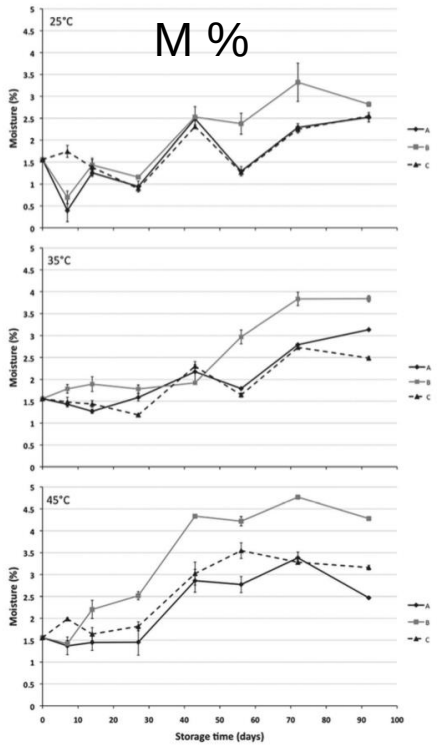
Romani et al. , J Sci Food Agric (2014)

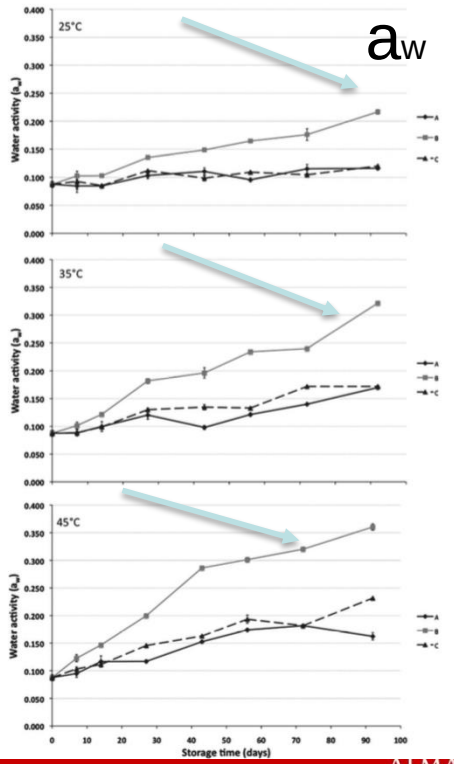
Table 1. Thickness and transmission rate characteristics of the packaging multilayer films

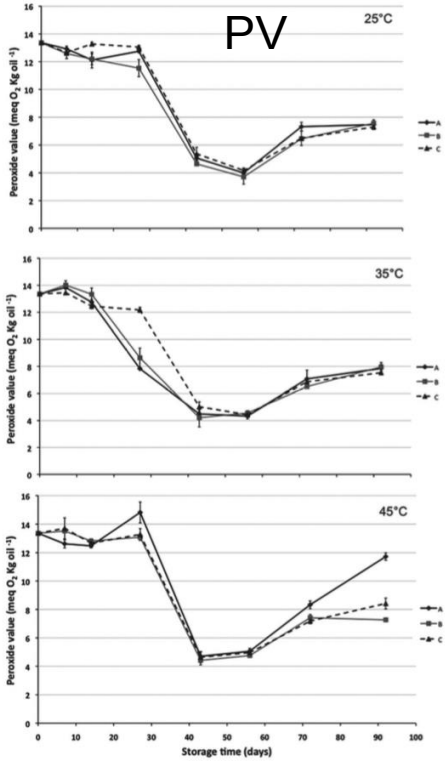
Packaging materials	Thickness (μm)	WVTR (g m^{-2} d^{-1})	O_2TR (cm^3 m^{-2} d^{-1})	CO_2TR (cm^3 m^{-2} d^{-1})
Met OPP/paper	63.14 ± 2.70b	0.50 ± 0.04a	9.94 ± 0.61b	58.17 ± 0.86b
Met PLA/paper *	57.16 ± 2.05a	2.24 ± 1.03b	1.61 ± 0.09a	4.01 ± 0.09a
Met OPP-EVA-POA/paper **	59.02 ± 2.09ab	1.95 ± 0.08b	14.97 ± 0.87c	81.30 ± 2.84c

* biobased & compostable

** partially biodegradable not compostable







No remarkable differences in the evolution of primary and secondary lipid oxidation were observed among differently packed biscuits during storage

samples in flexible packaging with EVA-POA and mainly PLA showed higher hydration

No dramatic effects on biscuit quality and safety since the low aw values

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Interdisciplinary Eco-friendly packaging project

ECOPACKLAB

Infrastructural laboratory for the application of advanced technologies to obtain active and eco-friendly packaging

Project Coordinator: Prof. Santina Romani

EcoPackLab

Project Description

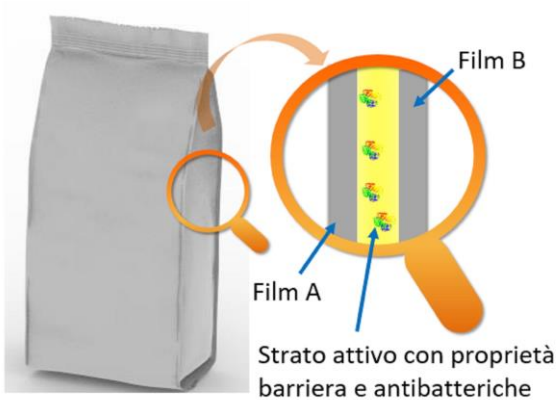
The project aims to create a sustainable and innovative packaging system for quality improvement in the storage of packaged foods. The project, through an integrated and interdisciplinary approach on quality, safety, sustainability and efficiency of logistics, makes use of two laboratories and industrial supply chains that provide the regional economy of their soft skills related to different areas of the food packaging industry.

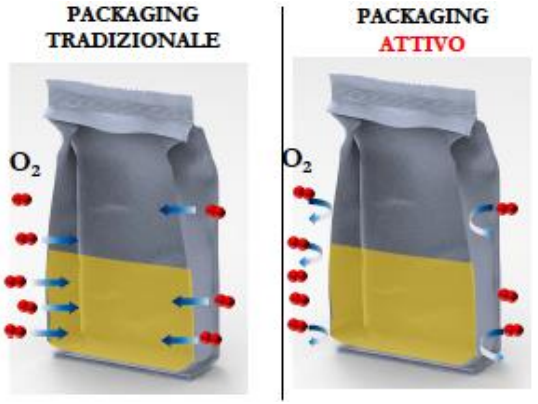
OBJECTIVES

-Creation of new multi-layer flexible film, coupled with advanced technology of cold plasma treatment, active and biodegradable.

- Improvement of stability, quality characteristics and extended shelf-life of foods packaged in new active packaging solutions, reducing and / or eliminating the use of preservatives in the formulation.

Biodegradabile Compostabile





PACKAGING MULTILAYER ATTIVO

CIRI ADVANCED APPLICATIONS IN MECHANICAL ENGINEERING AND MATERIALS TECHNOLOGY

CIRI AGRIFOOD

ROADMAP

from laboratory to industry

ILAPAK

IMA GIMA

Choice of materials

Multi-layer / single-layer solution validation

Choice of **active components**

Production and multilayer / monolayer characterization

Production and filling pouches

shelf life assessment

Scale-up On prototype machine

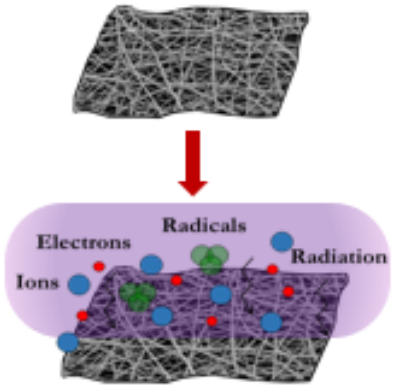
Barilla The Italian Food Company. Since 1877.

LCA Analysis

Multi-layer assembly step

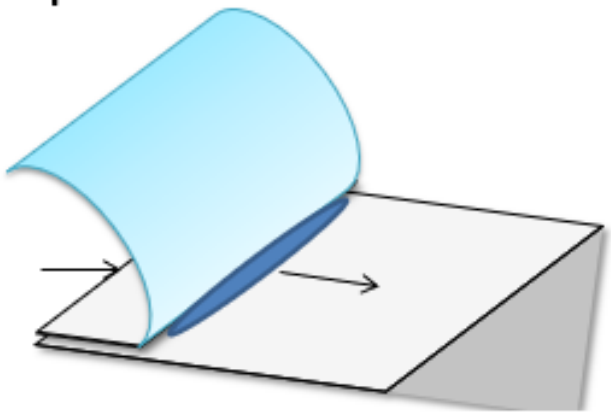
Multilayer production and characterization

1. **Trattamento plasma**



Funzionalizzazione plasma a freddo del PLA

2. Deposizione dello strato attivo



Deposizione manuale a lama del gel attivo

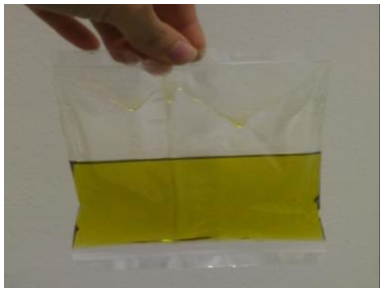
3. Accoppiamento e saldatura del multistrato

Termosaldatura laterale del multistrato

Stability analysis on model and food systems

Multilayer shelf-life studies / Oxygen Scavenger

Sample model systems (sunflower oil)

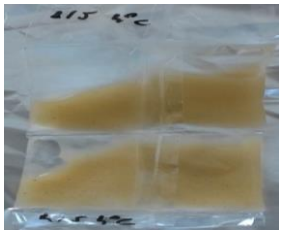


- **Control**
- **Multilayer active film (Oxygen scavenger)**

Real systems samples (Condiments / ready sauces)

- **Control**
- **Multilayer active film (Oxygen scavenger)**

Shelf-life studies Monolayer / Antimicrobial



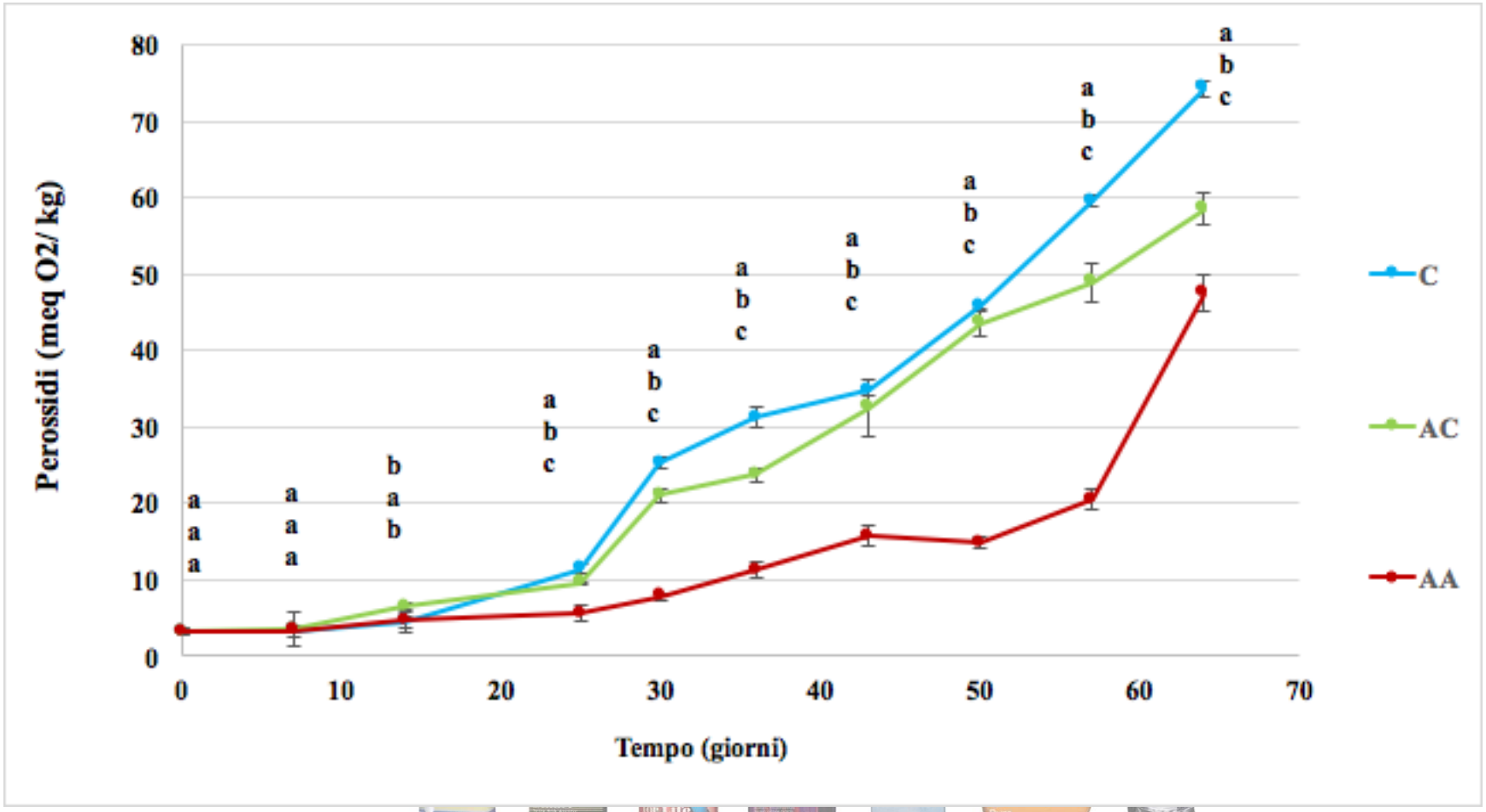
Model / real model samples (Smoothies based fruit and vegetables)

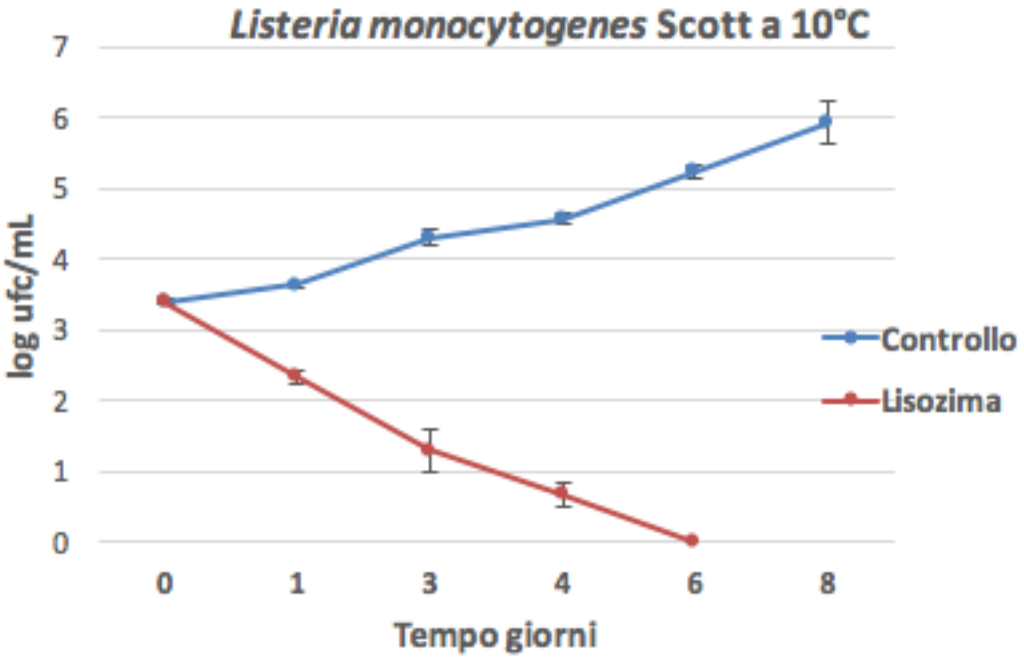
- **Control**
- **Active Film (Lisozima) Monolayer**

Peroxide Values

Sample model systems (sunflower oil)

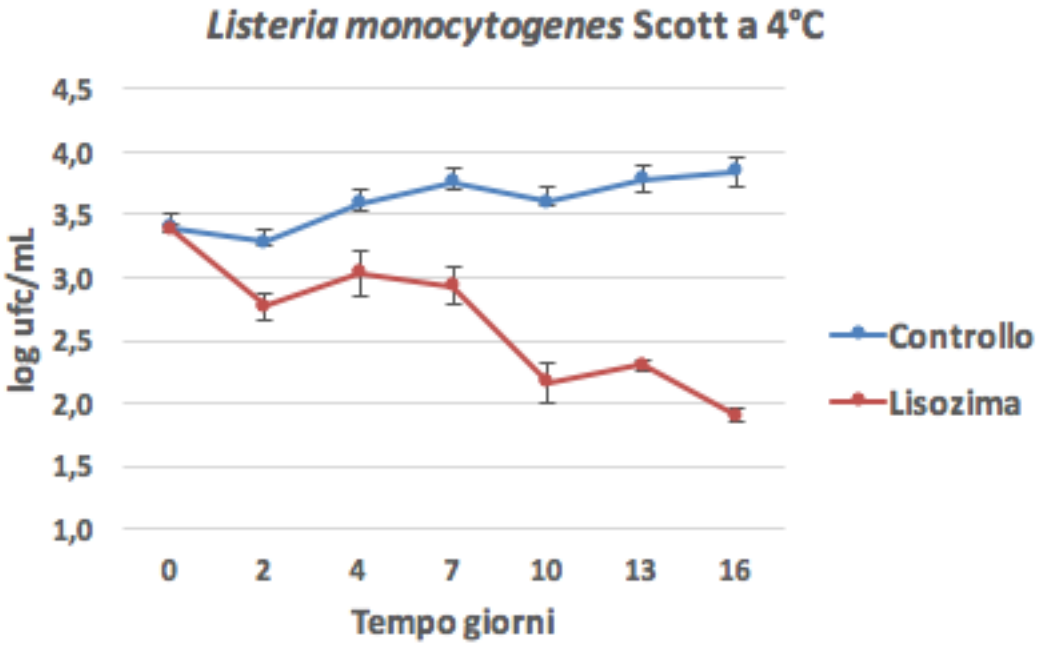
EcoPackLab

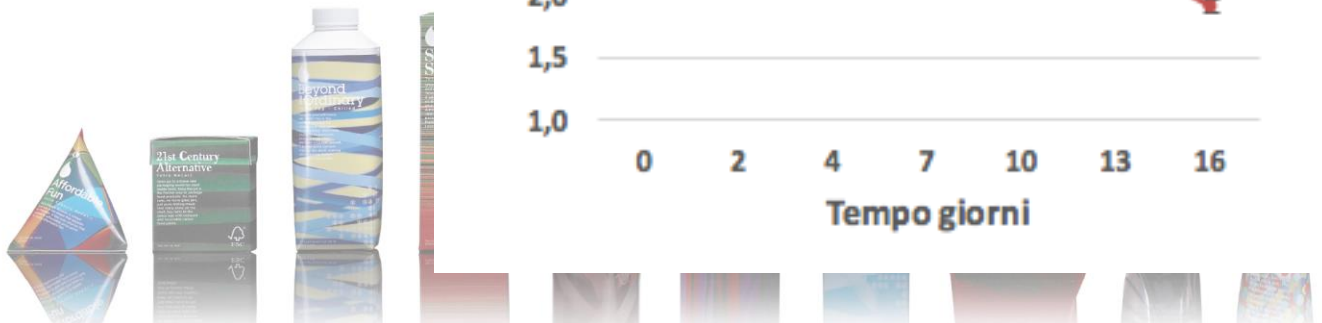




EcoPackLab

Model / real model samples
(Smoothies based fruit and vegetables)





Other Activated biopolymers

Corriere

Data 02-10-2016
Pagina 7
Foglio 1

bestack
Consorzio Bestack
via Miller, 32 - Forlì
www.bestack.com

Packaging anti-spreco? È quello in cartone ondulato di Bestack

A chiusura della Settimana dal Buon Vivere, il consorzio forlivese pone l'accento sulla sostenibilità in ortofrutta. "Grazie ai nostri imballaggi, ogni anno 850 mila tonnellate di prodotti e ritrebbero la spazzatura"

Bestack and Unibo patent "active" packaging

Annual estimated savings of over €190 million and 115 thousand tons of strawberries, apricots and nectarines that will not go to waste. In addition: fruit and vegetables look better, are fresher and healthier and last longer.

This is all thanks to the corrugated cardboard of "active" **Bestack** packaging, an innovative product that the company presented at Macfrut.

Fruit and vegetable crates are made of corrugated cardboard enhanced with a concentrated solution of natural essential oils that counter perishability. The product was developed in cooperation with the Comieco consortium.

http://www.freshplaza.com/article/163650/Bestack-and-Unibo-patent-active-packaging

Contribution of biopolymers to circular economy

Biobased materials, fill a need of the circular economy: to replenish a small but vital amount of resources that cannot be re-circulated sustainably

Applications of biomaterials will have significant impact on the safety and quality of the food supply (Clemens,Food Technology 3.14)

,

Influence and suitability *vs* different food needs

Non Respiring foods

High Water Resistance

Low GTR

Suitable to pasteurization / sterilization

Low heat transfer

Medium - high mechanical resistance

High Thermal Resistance

Not enough suitable performances in existing biobased & biodegradable packaging

Main challenge: Perfomances needed for food packaging

Comparison conventional *vs.* biopolymers

Unfortunately, generally speaking biodegradable polymers available today on the market lack in versatility and do not fulfilling all the requirements for a wide range of possible uses.

- High permeability - Gas transmission rate (GTR)
- Low stress-strain behavior
- Low deformation to break (ε_b)
- Low transparency

Possible solutions to improve film performances

I&EC research
Industrial & Engineering Chemistry Research

Article

pubs.acs.org/IECR

Fully Aliphatic Copolyesters Based on Poly(butylene 1,4-cyclohexanedicarboxylate) with Promising Mechanical and Barrier Properties for Food Packaging Applications

Matteo Gigli,[†] Nadia Lotti,*[,†] Massimo Gazzano,[‡] Valentina Siracusa,[§] Lara Finelli,[†] Andrea Munari,[†] and Marco Dalla Rosa[∥]

Principle: Synthesis of Homopolymers

PBCE and Poly(butylene cyclo-hexanedicarboxylate/diglycolate) Copolymers

Biodegradable/Biocompostable
From renewable sources

copolymerization is the most interesting tool to tailor materials displaying the right combination of properties for the desired application.

Possible solutions to improve film performances

Mechanical properties

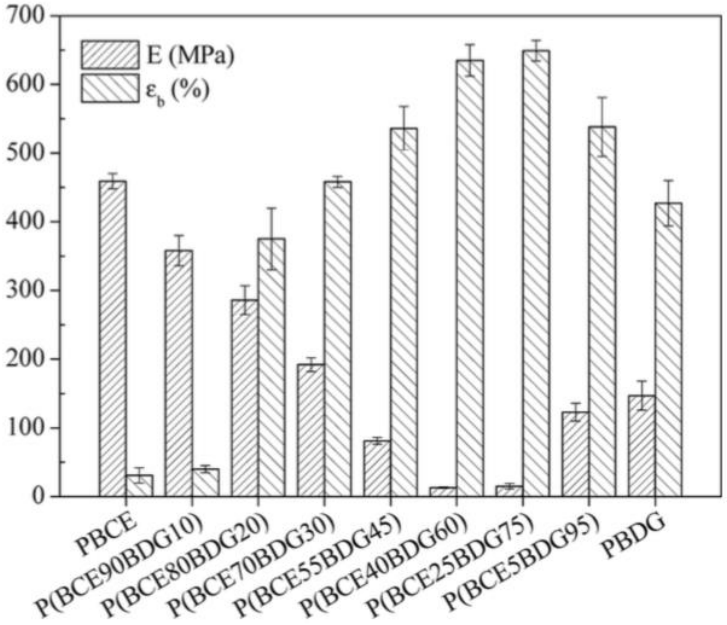


Figure 9. Elastic modulus (E) and deformation to break (ε_b) as a function of copolymer composition.

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

Possible solutions to improve film performances

Wettability

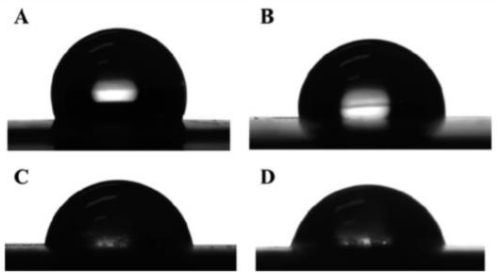
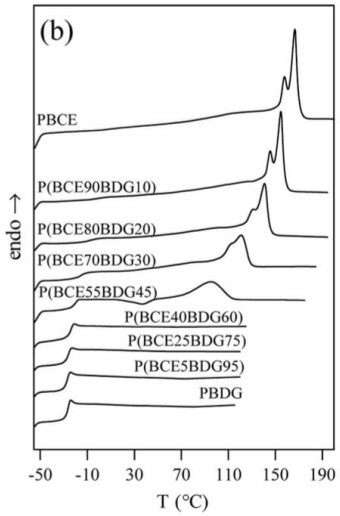


Figure 8. Water drops on the polymeric film surface of (a) PBCE, (b) P(BCE70BDG30), (c) P(BCE25BDG75), and (d) PBDG.



Thermal stability

simply varying the mutual ratio of the copolymer composition), it has been possible to obtain new polymers with different and improved characteristics with respect to the parent homopolymers

P(BCEmBDGn) copolyesters can be considered promising candidates for different eco-friendly food packaging applications ranging from rigid containers to flexible, even not suitable to subject to thermal treatments

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

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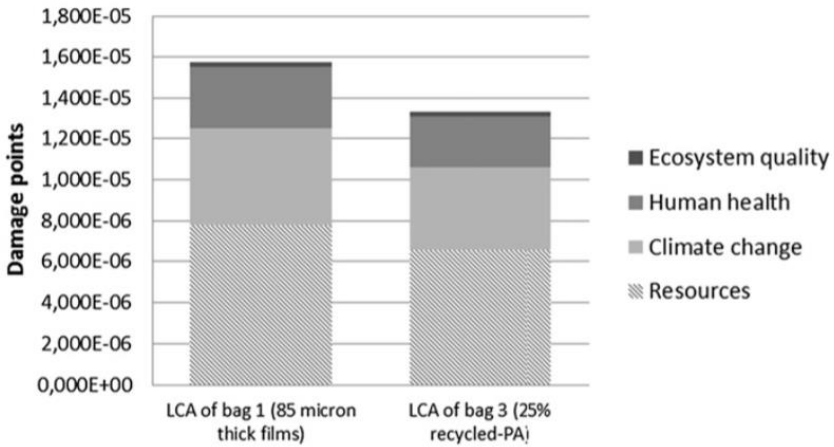
Substances emission and resource consumption.

Substance	Emission compartment	Amount	Units
Resources			
Gas natural in ground	–	66.4	dm^3
Oil, crude, 42.7 MJ per kg, in ground	–	74.2	g
Oil, crude, in ground	–	76.7	g
Climate Change			
Carbon dioxide	Air	207	g
Carbon dioxide, fossil	Air	254	g
Human Health			
Nitrogen oxides	Air	945	mg
Particulates < 2.5 μm	Air	40.8	mg
Sulphur dioxide	Air	655	mg
Hydrocarbons, aromatic	Air	3.28	mg
Ecosystem Quality			
Nitrogen oxides	Air	945	g
Zinc	Soil	157	mg
Aluminium	Soil	699	mg



LCA approach to consider resources consumption and impact of emissions

TECHNOPOLES

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- Selection of raw materials & ingredients
- Metabonomic, proteomic studies, metabolomic of raw materials, finished products and during storage
- Optimization of technological processing and fermentation
- Study of Packaging-Food interaction / Optimization of MAP / Active & biodegradable Packaging
- Formulation / Food design
- Shelf-life evaluation/ chemical, physical, microbiological, sensorial properties
- Valorization, nutrizional / functional enrichment and evaluation

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Thank you for your attention