

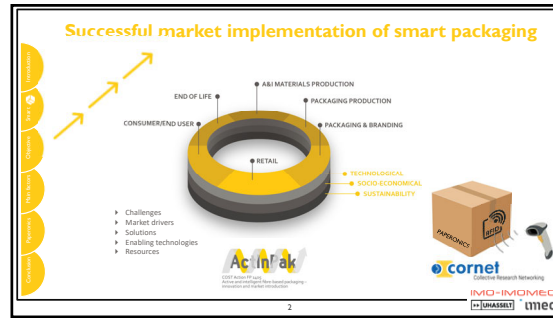
UHASSELT
UNIVERSITY OF APPLIED SCIENCES

MPR&S
Materials and Packaging Research & Services

Hollistic approach to a successful market implementation of smart packaging

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packcontact



Packaging – we want so much

Value Perception of Packaging GEN Y (*1980-2000)

173 kg packaging waste/EU inhabitant (2017)

European Circular Economy Action Plan, March 2020
→ all packaging is reusable or recyclable by 2030

- the essential requirements for packaging (Directive 94/62/EC) are under revision + new measures
- aimed at reduction of packaging waste
- driving design for re-use and recyclability
- considering less complexity of packaging materials

SUSTAINABILITY in functionality

- to guarantee product quality
- to guarantee product safety
- to minimize product waste

SUSTAINABILITY in materials

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Food waste

33% OF FOOD PRODUCED WORLDWIDE IS NEVER EATEN!

THIS EQUALS

- 88 MILLION HEADS TO FEED EVERY YEAR
- 173 KG PER PERSON ENOUGH TO FEED 48.9 MILLION PEOPLE FOR A DAY
- 370 MILLION TONNES OF CO₂ EMISSIONS

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Food loss & food waste

FOOD IS WASTED EVERYWHERE:

- PRIMARY PRODUCTION: 11%
- FOOD PROCESSING: 19%
- RETAIL & WHOLESALE: 5%
- FOOD SERVICE & CATERING: 12%
- HOUSEHOLDS: 53%

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Food safety

37% OF EUROPEANS WORRY ABOUT FOOD SAFETY. THEY ARE MAINLY CONCERNED ABOUT:

- QUALITY & FRESHNESS
- FOOD POISONING
- ADDITIVES & PRESERVATIVES

food safety
country of origin
cost
taste

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Food safety

AND RIGHTLY SO, BECAUSE:

- 200 THERE ARE OVER 200 DIFFERENT DISEASES THAT ARE SPREAD THROUGH FOOD
- 23 MILLION EUROPEANS FALL ILL EVERY YEAR DUE TO FOODBORNE ILLNESSES
- 1 IN 8 COUNTERFEITED PRODUCTS ARE FOODSTUFFS

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Smart packaging

- Active packaging** interacts with the packaged product in order to prevent quality loss and to prolong shelf life.
- Intelligent packaging** senses changes inside the packaging atmosphere and/or communicates about the quality of the product.

SCAVENGERS: Moisture, Oxygen, Ethylene

ADAPTORS: Biological, Chemical

EMITTERS: Moisture, Antimicrobials

- To inform about product quality
- To establish any brand-consumer connection
- To control tracking or counterfeiting conducts in the supply chain

RFID

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Ex. of active & intelligent packaging concepts

New Active Recyclable Packaging with Natural Antioxidising for the extension of the fresh food shelf life

Fresher foods with FRESHFILM packaging
EU-funded researchers have developed a new recyclable packaging film that extends the shelf life of meat and fresh produce.

FRESHFILM 2009-2011

Bio-based smart packaging for enhanced preservation of food quality.

BIOSMART 2017-2021

Bio-based smart packaging for enhanced preservation of food quality (BIOSMART) This project has the ambition to develop active and smart bio-based and compostable packages, addressing the needs of fresh and pre-treated food applications, as for example, light weightening, reduced residues, shelf life monitoring and longer shelf life, easier waste handling, and all this at a competitive cost. BIOSMART project develops this encompasses an approach for selectively integrating super-hydrophobic surfaces, microencapsulated phase change materials, barrier coatings, sensing devices, and new bio active antimicrobial and antioxidants, into all-bio-based multilayer flexible plastic packages.

Ex. of active & intelligent packaging concepts

HIGH PERFORMING ADVANCED MATERIAL PLATFORM FOR ACTIVE AND INTELLIGENT FOOD PACKAGING: CHRONOGARD™

New product dramatically improves the capabilities of food packaging

Keeping food longer on shelves will become an absolute priority for feeding the planet as the rise in temperature reduces crop yields. An EU initiative introduced an innovative product to significantly extend the life of packaged food.

CHRONOGARD 2017-2020

Granting society with Low environmental impact innovative PACKaging

GLOPACK 2018-2021

The main objectives of GLOPACK:

- GLOPACK focuses on developing the real ability of smart packaging technologies to improve the food packaging.
- GLOPACK focuses on the development of smart packaging technologies to improve the food packaging.
- GLOPACK focuses on the development of smart packaging technologies to improve the food packaging.

Ex. of active & intelligent packaging concepts

Innovative Packaging for the Detection of Fresh Meat Quality and Prediction of Shelf-Life

TOXDTECT 2013-2016

Intelligent packaging detects meat quality

An EU-funded consortium comprising European associations, research centres and SMEs developed an accurate, non-destructive and cost-effective method for determining the quality and shelf life of packaged meat.

A revolutionary quality indicator platform for the food industry

MultiSens 2017-2019

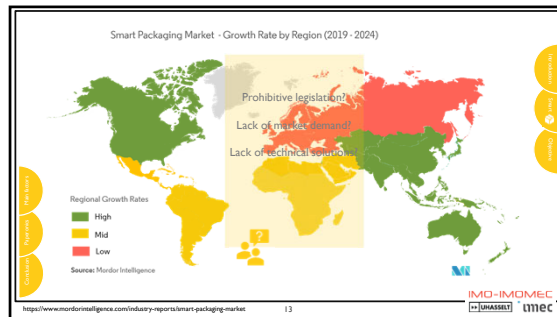
Intuitive freshness indicator helps consumers reduce food waste

The EU-funded MultiSens project's innovative freshness indicator can be integrated directly into food packaging.

AIP can reduce food waste and contribute to food safety

REDUCE GROWTH OF MICRO-ORGANISMS THAT CAUSE FOOD SPOilage & FOODBORNE ILLNESSES	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
SLOW DOWN RIPENING PROCESSES TO MAKE PRODUCTS LAST LONGER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
PREVENT PRODUCTS FROM GETTING SOGGY OR RANCID TO MAINTAIN TASTE & APPEARANCE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
REDUCE THE NEED FOR ADDITIVES & PRESERVATIVES IN FOODSTUFFS	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
MAINTAIN QUALITY & FRESHNESS AFTER THE PACKAGING HAS BEEN OPENED (SECOND SHELF-LIFE)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
			DETERMINE REMAINING SHELF LIFE MORE ACCURATELY AND REAL-TIME	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
			COMMUNICATE MORE CLEARLY ABOUT PRODUCT QUALITY & SHELF-LIFE	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
			COMMUNICATE MORE CLEARLY ABOUT FOOD SAFETY & SHELF-LIFE	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
			GUARANTEE THAT PRODUCTS ARE AUTHENTIC AND HAVE NOT BEEN TAMPERED WITH	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

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Research approach

COST Action FPI405 ActinPak (2015-2019)

- gathered over 400 participants, from research organizations, industry, branch organizations and policymakers from 34 European countries in the areas of papermaking, printing, packaging bio-based materials, and chemicals to openly discuss the market implementation of AIP
- resulted in technological, socio-economic & sustainability roadmaps directing future activities in the field.

Consumer survey among 1249 European millennials (Gen Y)

- the current value perception of packaging functions
- intentions to purchase AIP
- the willingness to buy AIP

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foods

Article

Hollistic Approach to a Successful Market Implementation of Active and Intelligent Food Packaging

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Main factors

Most influential factors in successful market implementation on socio-economic level:

- Market drivers that affect developments
- Gap between science and industry
- Gap between legislation and practice
- Cooperation between the producing stakeholders within the value chain
- Gap between industry and consumer

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1. Market drivers that affect developments

A&I COMPONENT PRODUCER | PACKAGING PRODUCER | PACKER / BRAND OWNER | RETAILER | CONSUMER / END USER

Sustainability goes mainstream

- reduction, recyclable, reusable, biobased, biodegradable
- plastics vs fiber-based materials?
- shelf life
- infrastructure and production processes

The internet-of-things

- e-commerce
- tracking & tracing
- interactive packaging
- consumer engagement & data collection

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2. Gap between science and industry

Science works for >30 years on smart packaging concepts

- There is a **lack of awareness on AIP**, its benefits, added value and impact.
- Scientific publications will not help, but **communication** targeted towards industry is needed.
- Opportunities for AIP technologies should be discussed with engineers, marketers, designers, purchasers, etc... preferably using a "proven" demonstrator to show the potential of the solution.

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3. Gap between legislation and practice

- EU legislation
 - Framework Regulation (EC) no. 1935/2004 (food contact materials)
 - Regulation (EU) no. 10/2011 (plastic FCM)
 - Regulation (EC) no. 2023/2006 (GMP)
 - Regulation (EC) no. 450/2009 (active & intelligent materials)
 - Individual substances must be safe and comply with the framework Regulation
 - EFSA evaluation → positive community list
 - New guidance document of 27 March 2021

Administrative guidance for the preparation of applications on substances to be used in active and intelligent materials and articles intended to come into contact with food

<https://doi.org/10.2903/jep.efsa.2021.EN-6513>

4. Cooperation between stakeholders of the value chain

ABI COMPONENT PRODUCER	PACKAGING PRODUCER	PACKER / BRAND OWNER	RETAILER	CONSUMER / END USER
Dependency Costs vs revenues Availability Legislation	Awareness Costs vs revenues Availability Legislation	Awareness Costs vs revenues Trust in technology Legislation	Awareness Costs vs revenues Transparency Trust in technology Reliability Legislation	Awareness Costs vs revenues Trust in technology Perception Way of communication

► Mutual challenges can be overcome by increased communication and cooperation

► Conflicting interests can create boundaries

5. Gap between industry and consumer

- Again, there is a lack of awareness, so informing and educating consumers might prove to be beneficial.
 - Unknown or invisible extra features in a packaging might be perceived as suspicious and benefits might be unknown and unclear.
 - AIP features should not be too complicated for a consumer:
 - no misunderstanding
 - the way information is presented, will also affect consumer trust.
- More research is needed in this area to explore the perception of different consumer groups, e.g. elderly, gen Y, gen Z, ...

European consumer perception of smart packaging

- Value perception
 - Scale 1-7

Table 1: Mean values (standard deviations) for respondents' perceived purchase intention of AIP

Would you buy...	Global	Male	Female	Y	Z	Gen X	Gen Y
Packaging that improves the safety of the product	4.63 (0.85)	4.58 (0.85)	4.68 (0.84)	4.76 (0.84)	4.58 (0.84)	4.58 (0.84)	4.58 (0.84)
Packaging that improves the convenience of the product	4.21 (0.71)	4.24 (0.71)	4.18 (0.71)	4.24 (0.71)	4.18 (0.71)	4.24 (0.71)	4.18 (0.71)
Packaging that improves the appearance of the product	3.89 (0.64)	3.92 (0.64)	3.86 (0.64)	3.92 (0.64)	3.86 (0.64)	3.92 (0.64)	3.86 (0.64)
Packaging that improves the sustainability of the product	3.57 (0.57)	3.60 (0.57)	3.54 (0.57)	3.60 (0.57)	3.54 (0.57)	3.60 (0.57)	3.54 (0.57)
Packaging that improves the functionality of the product	3.25 (0.50)	3.28 (0.50)	3.22 (0.50)	3.28 (0.50)	3.22 (0.50)	3.28 (0.50)	3.22 (0.50)
Packaging that improves the taste of the product	2.93 (0.43)	2.96 (0.43)	2.90 (0.43)	2.96 (0.43)	2.90 (0.43)	2.96 (0.43)	2.90 (0.43)
Packaging that improves the shelf life of the product	2.61 (0.36)	2.64 (0.36)	2.58 (0.36)	2.64 (0.36)	2.58 (0.36)	2.64 (0.36)	2.58 (0.36)
Packaging that improves the portability of the product	2.29 (0.29)	2.32 (0.29)	2.26 (0.29)	2.32 (0.29)	2.26 (0.29)	2.32 (0.29)	2.26 (0.29)
Packaging that improves the ease of use of the product	1.97 (0.22)	2.00 (0.22)	1.94 (0.22)	2.00 (0.22)	1.94 (0.22)	2.00 (0.22)	1.94 (0.22)
Packaging that improves the freshness of the product	1.65 (0.15)	1.68 (0.15)	1.62 (0.15)	1.68 (0.15)	1.62 (0.15)	1.68 (0.15)	1.62 (0.15)
Packaging that improves the healthiness of the product	1.33 (0.08)	1.36 (0.08)	1.30 (0.08)	1.36 (0.08)	1.30 (0.08)	1.36 (0.08)	1.30 (0.08)
Packaging that improves the nutritional value of the product	1.01 (0.01)	1.04 (0.01)	0.98 (0.01)	1.04 (0.01)	0.98 (0.01)	1.04 (0.01)	0.98 (0.01)
Packaging that improves the overall quality of the product	0.69 (0.04)	0.72 (0.04)	0.66 (0.04)	0.72 (0.04)	0.66 (0.04)	0.72 (0.04)	0.66 (0.04)

Food 2021, 10, 465. <https://doi.org/10.3390/foods10020465>

European purchase intention of smart packaging

- Scale 1-7

Table 2: Mean values (standard deviations) for respondents' perceived purchase intention of AIP

Would you buy...	Global	Male	Female	Y	Z	Gen X	Gen Y
Packaging that improves the safety of the product	4.63 (0.85)	4.58 (0.85)	4.68 (0.84)	4.76 (0.84)	4.58 (0.84)	4.58 (0.84)	4.58 (0.84)
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Packaging that improves the appearance of the product	3.89 (0.64)	3.92 (0.64)	3.86 (0.64)	3.92 (0.64)	3.86 (0.64)	3.92 (0.64)	3.86 (0.64)
Packaging that improves the sustainability of the product	3.57 (0.57)	3.60 (0.57)	3.54 (0.57)	3.60 (0.57)	3.54 (0.57)	3.60 (0.57)	3.54 (0.57)
Packaging that improves the functionality of the product	3.25 (0.50)	3.28 (0.50)	3.22 (0.50)	3.28 (0.50)	3.22 (0.50)	3.28 (0.50)	3.22 (0.50)
Packaging that improves the taste of the product	2.93 (0.43)	2.96 (0.43)	2.90 (0.43)	2.96 (0.43)	2.90 (0.43)	2.96 (0.43)	2.90 (0.43)
Packaging that improves the shelf life of the product	2.61 (0.36)	2.64 (0.36)	2.58 (0.36)	2.64 (0.36)	2.58 (0.36)	2.64 (0.36)	2.58 (0.36)
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Packaging that improves the nutritional value of the product	1.01 (0.01)	1.04 (0.01)	0.98 (0.01)	1.04 (0.01)	0.98 (0.01)	1.04 (0.01)	0.98 (0.01)
Packaging that improves the overall quality of the product	0.69 (0.04)	0.72 (0.04)	0.66 (0.04)	0.72 (0.04)	0.66 (0.04)	0.72 (0.04)	0.66 (0.04)

Food 2021, 10, 465. <https://doi.org/10.3390/foods10020465>

Willingness to pay extra for smart packaging

Figure 2021, 10, 468

75% Willingness to pay extra for smart packaging

85% Willingness to pay extra for smart packaging

Food 2021, 10, 465. <https://doi.org/10.3390/foods10020465>

Holistic view on the implementation of smart packaging

- Active packaging vs intelligent packaging

IMO-IMOMEC logo

PAPERONICS

- Printed electronics on fiber-based substrates
- RFID smart packaging flow

	Chip manufacturing	Antenna manufacturing (chip + antenna)	Tag assembly	Label conversion	Package integration
Today	Company 1	Company 2	Company 3	Company 4	Packaging company
Paperonics	Company 1	Packaging company			
Future	Packaging company				

PAPERONICS value chain

6 Research Partners

34 Industrial Partners

PAPERONICS objective

To design and develop smart packaging demonstrators by integrating (printed) electronic components as smart labels in cardboard packaging.

Demo 1: Customer relationship product

Logos: cornet, IMMO-IMOMEC, tmecc, KU Leuven, IVLW, Fraunhofer, PTS, AF

PAPERONICS objective

To design and develop smart packaging demonstrators by integrating (printed) electronic components as smart labels in cardboard packaging.

Demo 1: anti-tampering packaging

Demo 2: temperature indicator

Demo 3: customer relationship product

Logos: cornet, IMMO-IMOMEC, tmecc, KU Leuven, IVLW, Fraunhofer, PTS, AF

PAPERONICS approach

- Selection of best paper/ink combinations out of 76 paper substrates and 2 silver inks based on paper air permeance, surface roughness, thermal stability and sheet resistance characteristics.
- Screen printing antennas and electrical characterization.
- Tag assembly by connecting a flexible thin-film HF RFID chip (13.56 MHz) on top of the antenna with conductive adhesive.
- Testing functionality of RFID labels.
- Investigation of potential RFID customer relationship applications.
- Design and development of smart packaging demonstrators.
- Functionality and reliability testing of the cardboard demo boxes.

Logos: cornet, IMMO-IMOMEC, tmecc, KU Leuven, IVLW, Fraunhofer, PTS, AF

Ideas for use of RFID's in paper/cardboard applications

Track & trace	Product authentication	Consumer interaction
<ul style="list-style-type: none"> Logistic labels to track goods E-commerce RFID in medicine packaging on the secondary packaging (box) Sustainable packaging Remote reading of mouse and rat traps in larger complexes such as industrial or hospital sites 	<ul style="list-style-type: none"> Smart (medical) packaging with leaflet information in multiple languages that can be read via mobile devices or speech Product information for niche products (e.g. perfumes of high-end brands) Counterfeiting Prevention of alcoholic beverages for underaged people 	<ul style="list-style-type: none"> Smart (medical) packaging with leaflet information in multiple languages that can be read via mobile devices or speech RFID on (Tyeck) wristbands and back numbers Applications to make lectures and events interactive

Logos: IMMO-IMOMEC, tmecc

Reusable cardboard box with RFID label for 3rd party logistics

IDEA: circular packaging in logistics

- Sustainable, reusable and foldable secondary packaging

Logos: IMMO-IMOMEC, tmecc

Reusable cardboard box with RFID label for 3rd party logistics

IDEA: circular packaging in logistics

- Sustainable, reusable and foldable secondary packaging
- Functionality and reliability testing
- Software tool to support the logistic cycle

Logos: IMMO-IMOMEC, tmecc

materials MDPI

Screen Printed Antennas on Fiber-based Substrates for Sustainable HF RFID Assisted e-Fulfillment Smart Packaging

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Conclusion

- Successfully assembled RFID labels can be integrated in sustainable smart packaging, which can be used for e-fulfillment purposes.
- Other smart packaging applications were demonstrated too.

- We conclude that this multidisciplinary approach is a good example for future implementation of hybrid electronics in sustainable smart packaging solutions.

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