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Modules from the BIP FOOD INNOVATION AND THE CONSUMER

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FOOD INNOVATION
AND THE CONSUMER

BLENDED INTENSIVE PROGRAM | ONLINE: 10 - 31 March 2025 | **FACE-TO-FACE:** 4 - 11 April 2025

PARTNERS: UNIVERSITAT POLITÈCNICA DE VALÈNCIA | U.PORTO FACULDADE DE CIÊNCIAS UNIVERSIDADE DO PORTO | HELLENIC REPUBLIC National and Kapodistrian University of Athens

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4.3 New Food Packaging

Susana Caldas Fonseca

FOOD INNOVATION
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4.3 New Food Packaging

- 4.3.1. Smart Packaging
  - Active Packaging
  - Intelligent Packaging
- 4.3.2. New Food Packaging Materials
  - Environmental Impact of Packaging Residues and New Materials
  - Recycled Material
  - Biodegradable Material
  - Edible Material (Edible Coatings)

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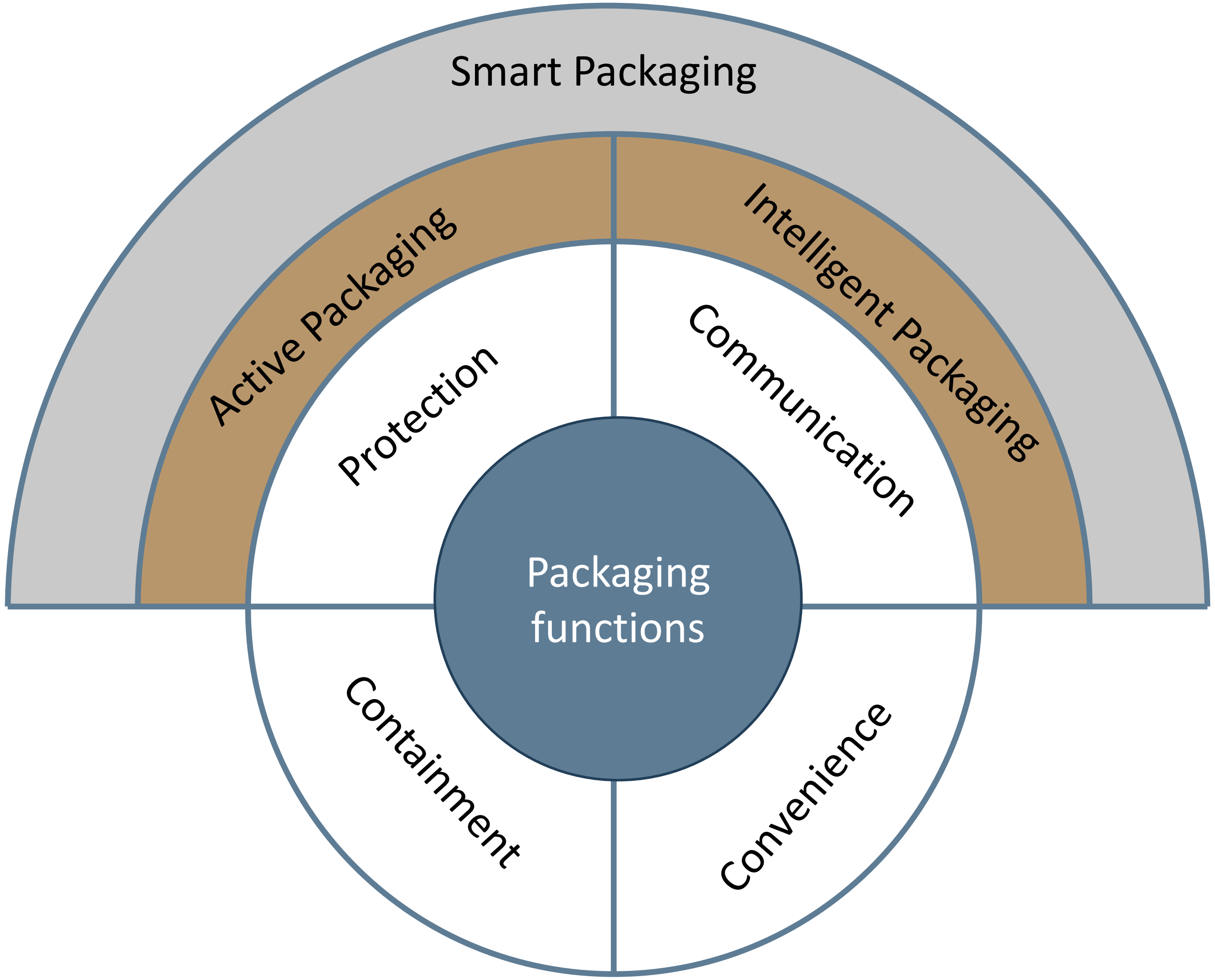
4.3.1 Smart Packaging



PASSIVE PACKAGING

The basic functions are:

- containment
- protection (and preservation)
- communication and
- convenience (service)

SMART PACKAGING

They are designed to improve the functions of passive packaging:

- Allow interaction with the product in order to maintain its quality

Active Packaging → Increase Protection

- Respond to product changes by communicating it to the consumer

Intelligent Packaging → Increase Communication

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Active Packaging: definition and objectives

Active Packaging is a packaging system that actively alters the conditions surrounding the product with the aim of its preservation (reducing deterioration, maintaining quality and safety and increasing shelf life).

- There is an interaction between **active agents** (present in the packaging or in packaging components) and the product, which leads to the control of the phenomena of:
  - Respiration
  - Spoilage
  - Maturation
  - Transpiration

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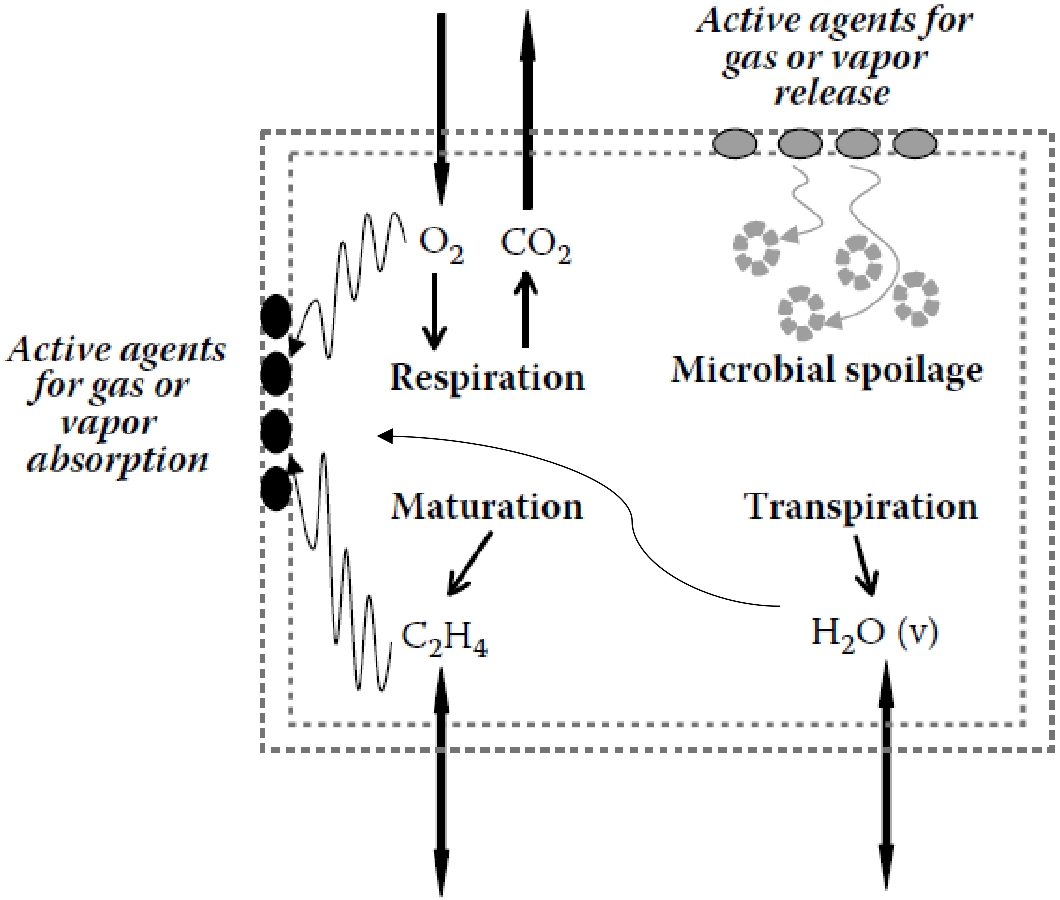

FIGURE 16.4 Relations between physiological phenomena and packaging permeation and absorption/releasing properties in active MAP.

Source: Robertson GL (2010) Food Packaging and Shelf Life: a Practical Guide. CRC Press
https://doi.org/10.1201/9781420078459

Types of active packaging

The most common are:

- **Absorbing/scavenging Systems**
  - Packaging with water/moisture absorbers
  - Packaging with ethylene scavengers
  - Packaging with oxygen scavengers,
  - Packaging with carbon dioxide scavengers, …
- **Releasing Systems**
  - Antimicrobial packaging
  - Packaging with carbon dioxide emitters
  - Packaging with antioxidant emitters
  - Packaging with aroma/flavor emitters, enzymes, …

EU Guidance to the Commission Regulation (EC) No 450/2009 of 29 May 2009 on active and intelligent materials and articles intended to come into contact with food.

Kadirvel, V., Palanisamy, Y., & Ganesan, N. D. (2025). Active Packaging System-An Overview of Recent Advances for Enhanced Food Quality and Safety. *Packaging Technology and Science*, *38*(2), 145-162. https://doi.org/10.1002/pts.2863

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Types of active packaging

Active absorbing systems	Active releasing systems
remove negatively-acting compounds of the food or the atmosphere inside the package	**add positively-acting** compounds to the food or to the atmosphere inside the package

Types of active packaging

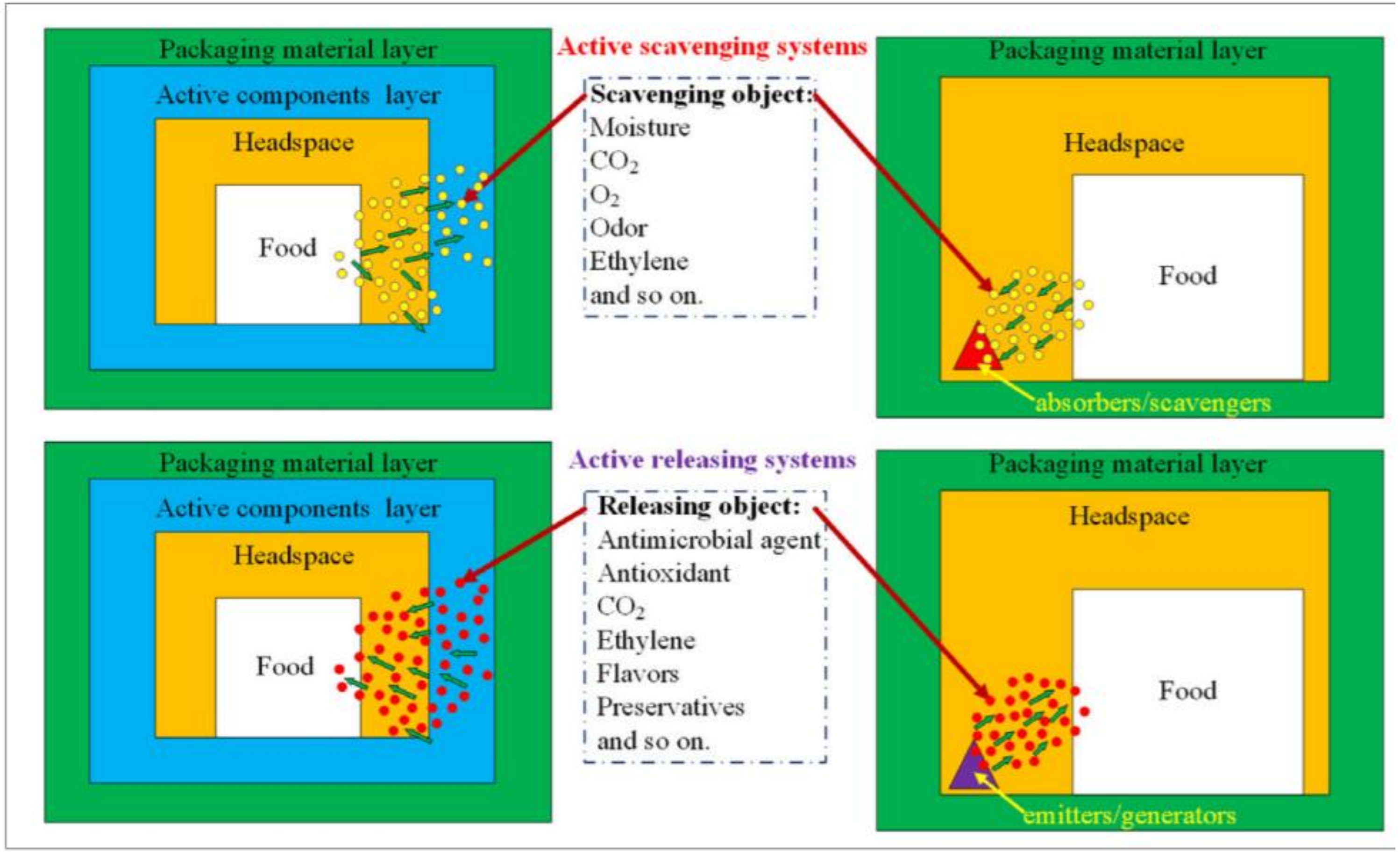

Figure 5–Schematic diagram for active food packaging systems.

Han, J. W., Ruiz-Garcia, L., Qian, J. P., & Yang, X. T. (2018). Food Packaging: A Comprehensive Review and Future Trends. Comprehensive Reviews in Food Science and Food Safety, 17(4), 860-877. https://doi.org/10.1111/1541-4337.12343

Types of active packaging

Fig. 2. Active agents for active food packaging.

Vilela, C., Kurek, M., Hayouka, Z., Röcker, B., Yildirim, S., Antunes, M. D. C., Nilsen-Nygaard, J., Pettersen, M. K., & Freire, C. S. R. (2018). A concise guide to active agents for active food packaging. Trends in Food Science & Technology, 80, 212-222. https://doi.org/10.1016/j.tifs.2018.08.006

Types of active packaging

Table 1–Potential active packaging for food applications.

Type of active packaging	Type of food	Potential benefit
Active scavenging systems (absorber)		
Oxygen scavenger	(Sliced) cooked meat products	Prevention of discolouration
	Grated cheese, (par-baked) bakery products	Prevention of mold growth
	Fruit and vegetable juices	Retention of vitamin C content, prevention of browning
	Seeds, nuts, and oils; fat-containing instant powders, fried snacks; dried meat products	Prevention of rancidity
Moisture scavenger	Mushrooms, tomatoes, strawberries, maize, grains, seeds, fresh fish, and meat	Extension of shelf life through maintaining moisture content, decrease in moisture condensation in the packaging, positive impact on the appearance, reduction in browning or discoloration
Ethylene absorber	Climacteric fruits and vegetables	Reduction in ripening and senescence, thereby enhancing quality and prolonging shelf-life
Active releasing systems (emitter)		
Antioxidant releaser	Fresh fatty fish and meat; fat-containing instant powders; seeds, nuts, and oils; fried products	Improvement of oxidative stability
Carbon dioxide emitter	Fresh fish and meat	Extension of microbiological shelf life, reduction in head space volume of modified atmosphere packaging
Antimicrobial packaging systems	Fresh and processed meat, fresh and smoked fish, fresh seafood, dairy products, fresh and processed fruits and vegetables, grain, cereals and bakery products, ready-to-eat meals	Inhibition or retardation of bacterial growth, extension of the shelf-life

Yildirim, S., Röcker, B., Pettersen, M. K., Nilsen-Nygaard, J., Ayhan, Z., Rutkaite, R., Radusin, T., Suminska, P., Marcos, B., & Coma, V. (2018). Active Packaging Applications for Food. Comprehensive Reviews in Food Science and Food Safety, 17(1), 165-199. https://doi.org/10.1111/1541-4337.12322

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Types of active packaging

ACTIVE AGENTS

Antimicrobial agents
- Biomaster®
- Aglon®
- Irgaguard®
- Surfacine®
- IonPure®
- Bactiblock®
- Biomaster®
- Food-touch®
- Sanic Films
- SANICO®
- Wasaouro®

Antioxidant agents
- ATOX

Oxygen scavengers
- ActiTUF™
- Ageless®
- ATCO®
- Bioka
- Celox™
- Cryovac® OS2000
- FreshPax®
- OMAC®
- OxyGuard®
- OxyCatch®
- OxyRx®
- Shelfplus® O_2

Ethylene scavengers
- Bio-fresh
- Ethysorb
- Retarder®
- PEAKfresh®
- Profresh
- Bi-On®

Carbon dioxide emitters
- Superfresh
- CO_2Pad
- CO_2 Freshpads
- VerifraisTM
- Ageless® G
- FreshPax®
- McAirlaid's CO_2Pad

Fig. 1. Examples of commercial active agents for active food packaging.

Vilela, C., Kurek, M., Hayouka, Z., Röcker, B., Yildirim, S., Antunes, M. D. C., Nilsen-Nygaard, J., Pettersen, M. K., & Freire, C. S. R. (2018). A concise guide to active agents for active food packaging. Trends in Food Science & Technology, 80, 212-222. https://doi.org/10.1016/j.tifs.2018.08.006

Packaging with water/moisture absorbers

Water

Water promotes microbial growth

Water/Moisture absorber

- Pads used to absorb exudate (liquid) and moisture in packed meat and fish;
- Materials and objects that function solely on the basis of natural constituents, such as pads composed of 100% cellulose, do not fall within the definition of active materials and objects, as they are not deliberately designed to incorporate components that absorb substances;
- Absorbers based on: i) Silica ge; ii) Calcium oxid; or iii) Calcium chloride

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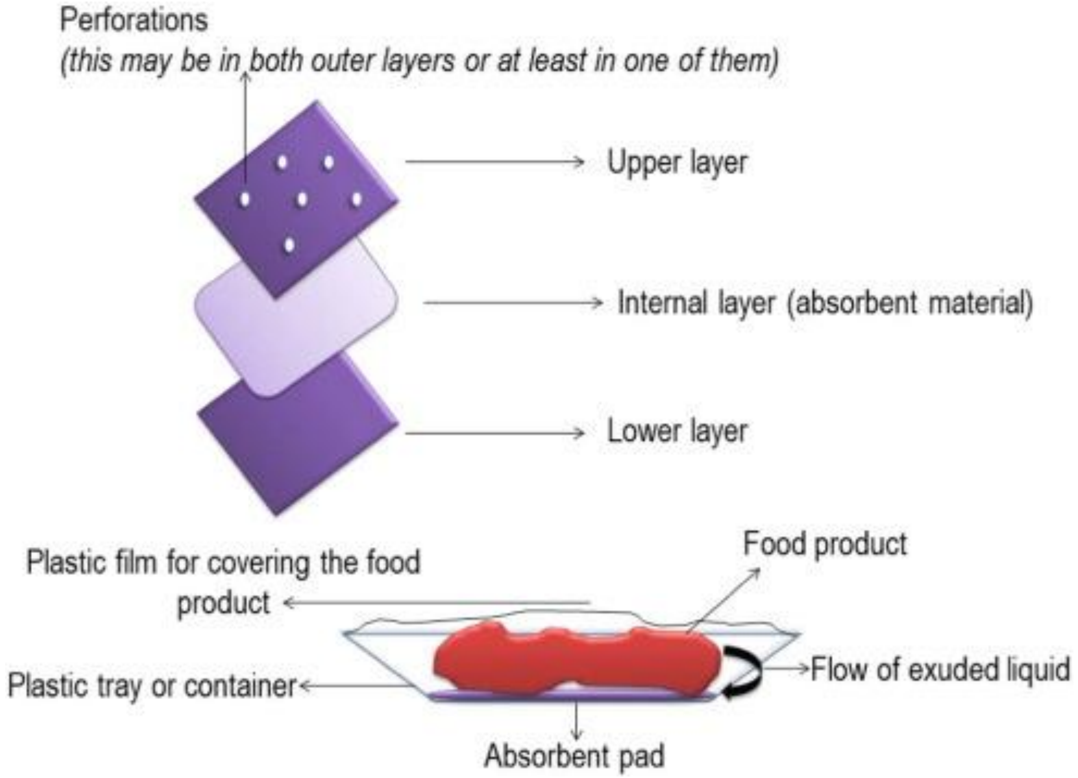
Packaging with water/moisture absorbers

FreshWell™ Absorbent Pad Systems
https://www.maxwellchase.com/product/absorbent-pads/

SEAWELL™ Protective Packaging Systems
https://www.maxwellchase.com/product/protective-packaging-systems/



Otoni, C. G., Espitia, P. J. P., Avena-Bustillos, R. J., & McHugh, T. H. (2016). Trends in antimicrobial food packaging systems: Emitting sachets and absorbent pads. Food Research International, 83, 60-73. https://doi.org/10.1016/j.foodres.2016.02.018

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Packaging with ethylene scavengers

Ethylene

Some fresh produce are sensitive to ethylene; the presence of ethylene accelerates its maturation and senescence

Ethylene scavengers

- Ethylene scavengers can be used in **sachets** inside the package or **incorporated** into the **polymer film.**
- Scavengers based on:
  - i) potassium permanganate ($KMnO_4$) in a silica gel matrix (in sachets)
  - ii) activated carbon (impregnated in polymer films)
  - iii) diatomaceous earth (finely dispersed and embedded in polymeric films)
  - iv) titanium dioxide (TiO_2) (nanoparticles embedded in polymer film)
  - v) palladium (embedded in polymer film)
  - vi) clay mineral nanotubes - aluminosilicate ($Al_2Si_2O_5(OH)$) (embedded in polymer film)

Suggestion:
Gaikwad, K. K., Singh, S., & Negi, Y. S. (2020). Ethylene scavengers for active packaging of fresh food produce. Environmental Chemistry Letters, 18(2), 269-284. https://doi.org/10.1007/s10311-019-00938-1

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Packaging with ethylene scavengers

Food application

In fresh produce. The most common examples of climacteric (ethylene emitters) fruits are: apples, pears, peaches, kiwi, tomatoes, avocados, bananas, mangoes, and papayas.

Table 2
Recent examples of carbon dioxide emitters, natural antioxidants, oxygen and ethylene scavengers incorporated into different matrices.

Active agent	Matrix	Food product	Reference
Ethylene scavenger			
$KMnO_4$	Silica (SiO_2) and alumina (Al_2O_3) nanoparticles	Tomato	Spricigo et al., 2017
TiO_2 nanoparticles	Chitosan	Cherry tomatoes	Kaewklin et al., 2018
Copper- and aluminium-based MOF	–	Banana	Chopra et al., 2017
Halloysite nanotubes (HNTs)	LDPE	Banana, tomato and strawberry	Tas et al., 2017
Palladium- and $KMnO_4$-promoted nano-zeolite	–	Tomato	Mansourbahmani et al., 2018

Vilela, C., Kurek, M., Hayouka, Z., Röcker, B., Yildirim, S., Antunes, M. D. C., Nilsen-Nygaard, J., Pettersen, M. K., & Freire, C. S. R. (2018). A concise guide to active agents for active food packaging. Trends in Food Science & Technology, 80, 212-222. https://doi.org/10.1016/j.tifs.2018.08.006

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Packaging with ethylene scavengers

Commercial examples

in sachets

Ethylene Control, Inc.
https://www.ethylenecontrol.com/

in incorporated polymeric film

Green bags, Evert-Fresh Corporation, USA
https://www.evertfresh.com/

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Packaging with oxygen scavengers

Oxygen

Promotes: i) oxidative reactions leading to color changes and oxidative rancidity of oils and fats; ii) mold growth; iii) pest growth (Insects).

Oxygen scavengers

- They are very common scavengers; used after active MAP to remove residual O_2 (< 0.01% v/v)
- Scavengers based on:
  - Iron (based on the absorption of O_2 from iron particles)
  - Palladium nanoparticles
  - a-tocopherol (vitamin E)
  - Ascorbic acid

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Packaging with oxygen scavengers

Food application

Bakery products, processed meats, smoked products, sausages, ham, cheeses, oils and fats, juices and wine, pre-prepared meals, ...

Table 2
Recent examples of carbon dioxide emitters, natural antioxidants, oxygen and ethylene scavengers incorporated into different matrices.

Active agent	Matrix	Food product	Reference
Oxygen scavenger			
Zero valent iron nanoparticles	Silicon	–	Foltynowicz et al., 2017
Palladium	PET/SiO_x	Ham	Yildirim et al., 2015
Titanium oxide nanotubes	–	–	Tulsyan et al., 2017
Ascorbic acid	–	Meatloaves	Lee et al., 2018
Pyrogallol	LDPE	Soybean oil	Gaikwad et al., 2017a, 2017b
Gallic acid	LDPE	–	Ahn et al., 2016
Gallic acid	Multilayered bio-based film	–	Pant et al., 2017
α-tocopherol	PLA microparticles	–	Scarfato et al., 2017
α-tocopherol-loaded PCL nanoparticles	Gelatin	–	Byun et al., 2012
Glucose oxidase	Ethylene-vinyl acetate	–	Wong et al., 2017
Laccase	Coated paper board, coated foil and free-standing films containing starch and different lignin derivatives	–	Johansson et al., 2014

Vilela, C., Kurek, M., Hayouka, Z., Röcker, B., Yildirim, S., Antunes, M. D. C., Nilsen-Nygaard, J., Pettersen, M. K., & Freire, C. S. R. (2018). A concise guide to active agents for active food packaging. Trends in Food Science & Technology, 80, 212-222. https://doi.org/10.1016/j.tifs.2018.08.006

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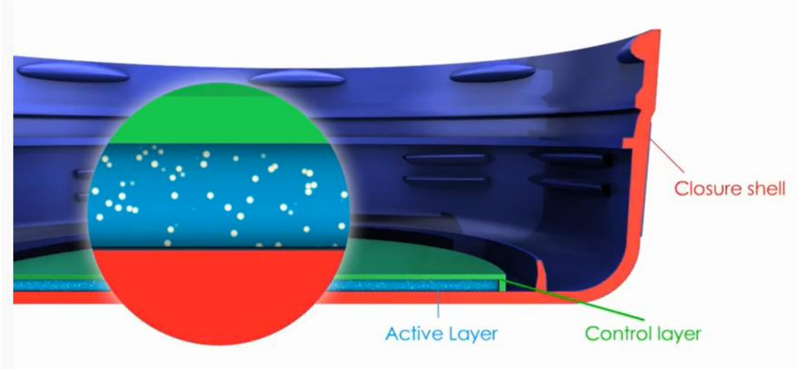
Packaging with oxygen scavengers

Commercial examples

in sachets, labels or on bottle caps

AGELESS® (OS-film, Mitsubishi Gas Chemical Inc., NY, U.S.A.)
http://ageless.mgc-a.com/product/ageless/



Hyguard^{TM} (Polyone)
https://www.polyone.com/products/polymer-additives/oxygen-scavengers

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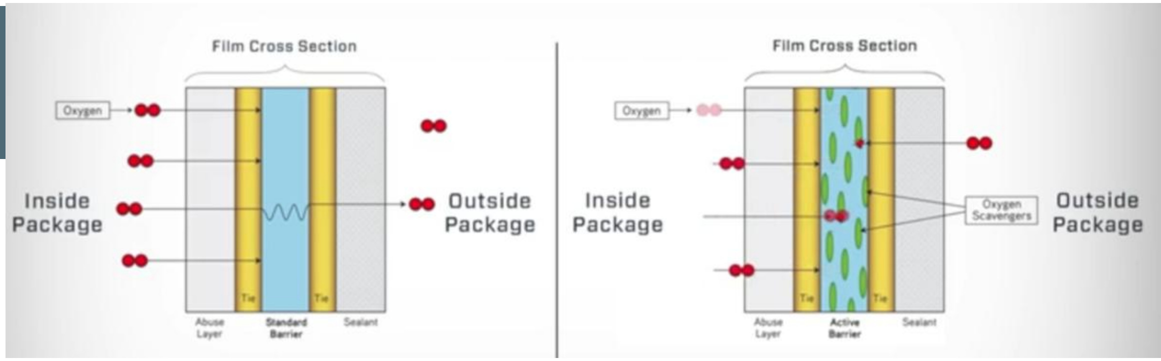
Packaging with oxygen scavengers

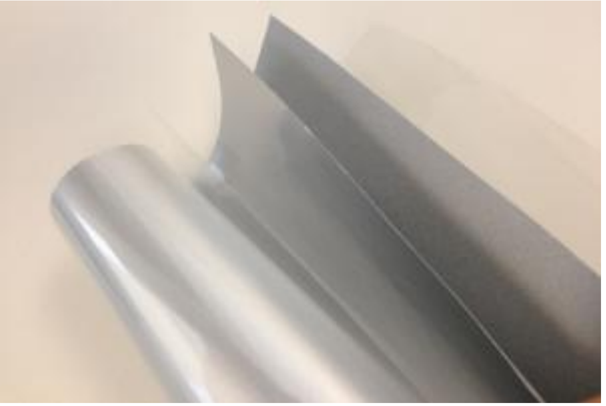
Commercial examples

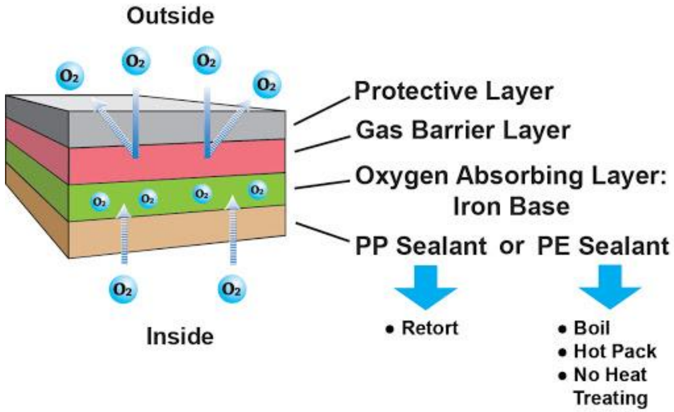
in incorporated polymeric film

SHELFPLUS® O_2 Oxygen Absorber
https://www.albis.com/en/products/products-brands/albis/SHELFPLUS%C2%AE-O2



Cryovac® Freshness Plus® (OSfilm, Sealed Air Corporation, Charlotte, NC, USA.)
https://sealedair.com/food-care/food-care-products/cryovac-freshness-plus-active-barrier





AGELESS OMAC® (OS-film, Mitsubishi Gas Chemical Inc., NY, U.S.A.)
http://ageless.mgc-a.com/product/ageless/

Packaging with carbon dioxide scavengers

Carbon dioxide

Excessive accumulation of CO_2 due to the respiration of fresh produce and the spoilage of fermented foods;
CO_2 release after coffee roasting

Carbon dioxide scavengers

- Physical scavengers based on:
  - zeolites (minerals with a porous structure - hydrated aluminosilicates),
  - activated carbon powder,
- Chemical scavengers based on:
  - Calcium hydroxide ($Ca(OH)_2$),
  - Sodium carbonate (Na_2CO_3),
  - Magnesium hydroxide ($Mg(OH)_2$), among others.

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Packaging with carbon dioxide scavengers

Food application

Applications in fresh produce, fermented foods and roasted coffee

Commercial examples

Table 3–Some commercial CO_2 absorbers used for food applications (Coma, 2008; Dong, 2016).

Year	Commercial name	Manufacturer	Form	Descriptions
2003*	ATCO® CO-450	Standa Industrie, France	Sachets	$Ca(OH)_2(s)+CO_2(g) \rightarrow CaCO_3(s)+H_2O(l)$
2008*	LitholymeTM	Allied Healthcare Products, Inc., USA	Granules	$CO_2 + H_2O \rightarrow H_2CO_3 + 2NaOH \rightarrow Na_2CO_3 + 2H_2O + Energy \rightarrow Na_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2NaOH$
2017*	Ageless® E	Mitsubishi Gas Chemical Inc., Japan	Sachets	$Ca(OH)_2(s)+CO_2(g) \rightarrow CaCO_3(s)+H_2O(l)$
NS*	Freshlock®	Multisorb Technologies Inc., USA	Sachets	$Ca(OH)_2(s)+CO_2(g) \rightarrow CaCO_3(s)+H_2O(l)$
NS*	EMCO®	EMCO Packaging Systems, Kent, UK	Sachets	$2NaCl+CO_2+NH_3+H_2O \rightarrow Na_2CO_3+3/2H_2O_2 \rightarrow Na_2CO_3+3/2H_2O+3/4O_2$
NS*	Zeolite 4A	Wako Pure Chemical Industries Ltd., Japan	Beads	Physical absorbers
NS*	Active carbon	Junsei Chemical Co.,Ltd., Japan	Powder	Physical absorbers

"NS": unknown year; "*": still commercially available.

Han, J. W., Ruiz-Garcia, L., Qian, J. P., & Yang, X. T. (2018). Food Packaging: A Comprehensive Review and Future Trends. Comprehensive Reviews in Food Science and Food Safety, 17(4), 860-877. https://doi.org/10.1111/1541-4337.12343

Antimicrobial packaging

Microbial Growth

Microbial (spoilage) growth leads to discoloration, the development of strange tastes and odors, changes in texture, and loss of nutritional value, reducing the shelf life of food;
Microbial (pathogenic) growth leads to increased risk of foodborne illness.

Antimicrobial packaging

Based on:

- essential oils (cinnamon, oregano, basil, cloves, ...),
- enzymes (lysozyme, lactoferrin,...) and bacteriocins (nisin, natamycin,...);
- antimicrobial polymers (chitosan),
- organic acids and derivatives (citric acid, sorbic acid, allyl isothiocyanate, ...),
- nanoparticles of metal ions and oxides (silver, copper, gold, titanium dioxide, zinc oxide,...);
- chlorine dioxide, ethanol, sulfur dioxide.

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Antimicrobial packaging

Food application

Fruits (particularly in red fruits); meat and fish; cheese.

Table 1
Recent examples of antimicrobial agents incorporated into synthetic and bio-based polymer matrices.

Antimicrobial agent	Film forming polymer	Food product	Microorganism	Reference
ZnO nanoparticles	PLA	Apple	Bacterial, yeast and fungi	Li et al., 2017
Clove essential oil and zinc oxide nanorods	Gelatin	Shrimp	*Listeria monocytogenes* *Salmonella Typhimurium*	Ejaz et al., 2018
Clove essential oil	Soy protein isolate	Muscle fillets of bluefin tuna (*Thunnus thynnus*)	*Pseudomonas* spp. Lactic bacteria and enterobacterias counts	Echeverría et al., 2018
Nisin	PHB/PCL with organo-clays	Ham	*Lactobacillus plantarum* CRL691	Correa et al., 2017
Lactoferrin	Bacterial cellulose	Fresh sausages	*E. coli, S. aureus*	Padrão et al., 2016
Lactoferrin and lysozyme	PET	Salmon	H_2S-producing bacteria	Rollini et al., 2016
Lysozyme nanofibers	Pullulan	–	*S. aureus*	Silva et al., 2018
Chitosan	Chitosan	Pork slices	Total viable counts (TVC)	Wang et al., 2017

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Antimicrobial packaging

Commercial examples

- Sachets or pouches and pads that are sealed loose or affixed to the interior of a container
- Polymers with Intrinsic Antimicrobial Properties
- Incorporation of Antimicrobial Agents into Polymers

Fadiji, T., Rashvand, M., Daramola, M. O., & Iwarere, S. A. (2023). A Review on Antimicrobial Packaging for Extending the Shelf Life of Food. *Processes*, *11*(2), 590. https://doi.org/10.3390/pr11020590

Packaging with carbon dioxide emitters

- In fresh produce, meat, and fish for microbial growth inhibition.
- Simultaneously use with active MAP.
- Use of sodium bicarbonate ($NaHCO_3$) and citric acid

Table 2
Recent examples of carbon dioxide emitters, natural antioxidants, oxygen and ethylene scavengers incorporated into different matrices.

Active agent	Matrix	Food product	Reference
Carbon dioxide emitter			
Sodium bicarbonate and citric acid	Absorbent Pad Dri-Loc + MAP (60% CO_2, 40% N_2)	Cod (*Gadus morhua*)	Hansen et al., 2016
Sodium bicarbonate and citric acid	Sachet + MAP (100% CO_2)	Chicken	Holck et al., 2014
Sodium bicarbonate and citric acid	+ MAP (60% CO_2, 40% N_2)	Reindeer meat	Pettersen et al., 2014

Vilela, C., Kurek, M., Hayouka, Z., Röcker, B., Yildirim, S., Antunes, M. D. C., Nilsen-Nygaard, J., Pettersen, M. K., & Freire, C. S. R. (2018). A concise guide to active agents for active food packaging. Trends in Food Science & Technology, 80, 212-222. https://doi.org/10.1016/j.tifs.2018.08.006

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Packaging with oxygen emitters and carbon dioxide absorbers

- Designed to compensate for the high respiration rate of some fresh produce;
- Releases oxygen in a controlled way and absorbs carbon dioxide

OxyFresh (EMCO Fresh Technologies Ltd)

News | June 13, 2013

EFSA Approves EMCO's OxyFresh Technology

EFSA, the European Food Safety Authority has recently published their formal scientific opinion on EMCO's OxyFresh technology. OxyFresh is considered safe for direct food contact inside fresh food packages and, as such, is one of the first active packaging technologies to have gained this validation from EFSA.

In April, a European Food Safety Authority (EFSA) panel evaluated and approved the powder mixture of the active substances sodium carbonate peroxyhydrate coated with sodium carbonate and sodium silicate, bentonite, sodium chloride, sodium carbonate.

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Intelligent Packaging: definition and objectives

Intelligent Packaging is a packaging system that is capable of having intelligent functions (detection, monitoring, recording and communication regarding the shelf life, safety and quality of the product) that alerts to a problem and facilitates decision making.

- The development of elements that monitor the quality and safety and consequently the shelf life of food products and can communicate to the consumer or to the elements of the food chain is a trend that has been in strong development due to the strong expansion of information technologies (more economical, more powerful, more commonplace, …).

Types of intelligent packaging

- Indicators:
  - Time-temperature indicators
  - Gas indicators (O_2 and CO_2)
  - Freshness indicators (metabolites, microbial contamination)
  - Humidity indicators
- Biosensors (maturation, oxygen and microorganisms)

Some authors also include:

- Radio-Frequency Identification (RFID) and NFC tags
- Optical Barcodes (EAN-13, UPC, QR, …)
- Electronic Article Surveillance

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Time temperature indicators

Device that shows an irreversible change in a physical characteristic (color, ...) as a response to the history of temperatures it has suffered.

- The time-temperature indicator (TTI) will show, through a visual change easily perceptible by the human eye, whether or not the product is fresh (as it is to be consumed).
- This visual variation will alert consumers and the food industry, distribution and catering to the condition of the product, ensuring its correct conservation along the chain until consumption.

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Time temperature indicators

Requisites

- Ease of activation
- response to temperature or cumulative effect of time and temperature
- correlation with the time/temperature distribution chain
- correlation with food spoilage
- Accurate, fast and irreversible response
- .....

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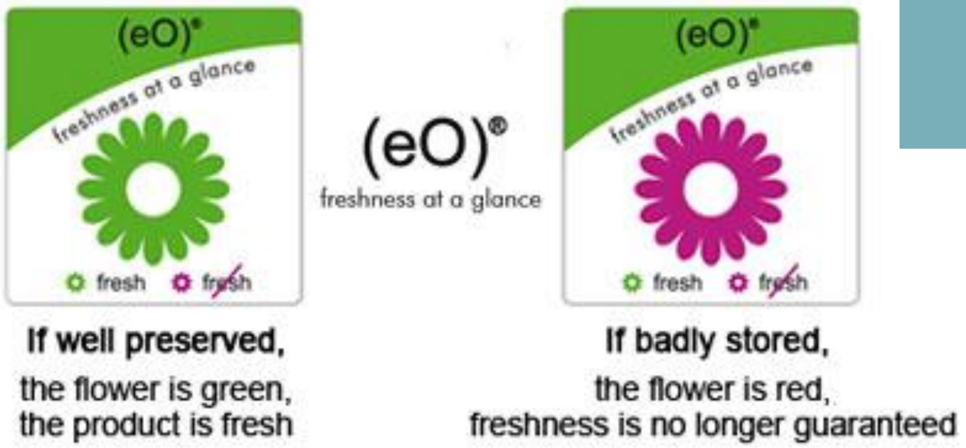
Time temperature indicators

Commercial examples

- TTI based on the microorganism *Carnobacterium maltaromaticum* and acid fuchsin as an indicator of color change.
- EFSA approved



European Food Safety Authority

EFSA approval for to be placed on the market: European regulation No. 450/2009.

See video:
https://www.youtube.com/watch?time_continue=8&v=wLnK5-T32rY&feature=emb_logo

TopCryo, Cryolog SA
http://cryolog.com/en/topcryo/

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Time temperature indicators

Commercial examples

3M™ MonitorMark™ Time Temperature Indicators
https://www.3m.co.uk/3M/en_GB/p/?Ntt=time+temperature+indicators

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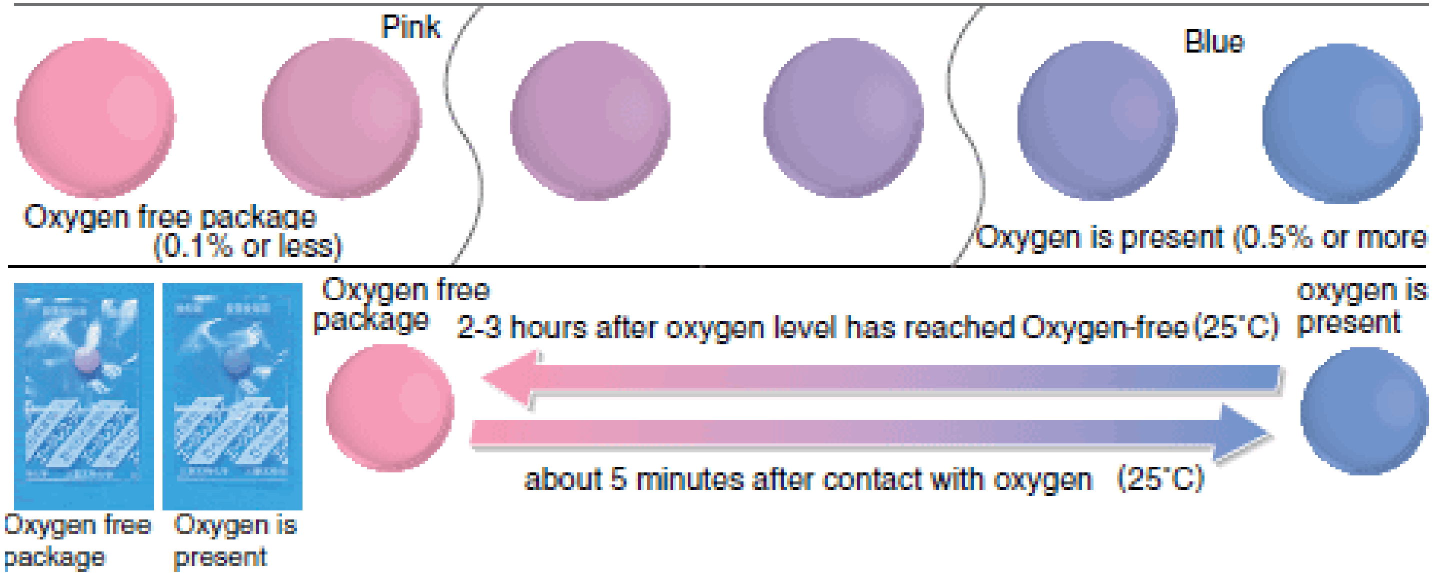
Oxygen biosensors

- To detect the presence of oxygen from a certain level (reversible system), check the sealing of the package or to check the breathability of the product.
- Presentation in sachets.



Ageless® Eye, Oxygen Indicator, Mitsubishi Gas Chemical
https://www.mgc.co.jp/eng/products/sc/ageless-eye.html

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RFID/NFC tags

- Radio Frequency Identification (RFID) technology in food labelling enables real-time tracking, enhanced traceability, and improved safety across supply chains.
- NFC (Near Field Communication) tags are small, wireless devices that store and transmit data wirelessly when activated by an NFC-enabled device (e.g., smartphones).

Avery Dennison
https://rfid.averydennison.com/content/dam/rfid/en/industries/Quick-Guide-RFID-Labels-for-Food-and-Beverage.pdf

Funded by the European Union

Smart packaging: European Regulatory framework

- General safety requirements are outlined in Regulation (EC) No 1935/2004, ensuring inertness unless exempted for active/intelligent functions. Active and intelligent food packaging materials are regulated under Regulation (EC) No 450/2009, which sets specific requirements for their safe use in the EU
- Pre-market approval is required, with substances evaluated by EFSA before inclusion in the EU's authorized substances list.
- Labelling rules mandate clear identification of non-edible parts (e.g., "Do not eat") and disclosure of released substances as food ingredients.
- EFSA assesses migration risks and toxicological data for substances used in these materials. Applicants must submit detailed dossiers, including manufacturing processes and safety evidence.
- Current Status
- While adoption has been slow, the legislation anticipates future growth in smart packaging solutions. Compliance requires a Declaration of Conformity at all supply chain stages.
- This framework ensures consumer safety while fostering innovation in food packaging

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Smart packaging: European Regulatory framework

- Regulation (EC) No 1935/2004 provides a harmonised legal EU framework. It sets out the general principles of safety and inertness for all Food Contact Materials (FCMs).
- In addition to the general legislation, certain FCMs — ceramic materials, regenerated cellulose film, plastics (including recycled plastic), as well as **active and intelligent materials** — are covered by specific EU measures.

Food, Farming, Fisheries

Food Safety

European Commission

Home | Food Safety | Animals | Plants | Horizontal topics

Home > Food Safety > Chemical safety > Food Contact Materials

Food Contact Materials

PAGE CONTENTS

Further information

The following web pages concern legislation on food contact materials (FCMs) in the EU.

Food comes into contact with many materials and articles during its production, processing, storage, preparation and serving, before its eventual consumption. Such materials and articles include food packaging and containers, machinery to process food, and kitchenware and tableware.

These materials are called **Food Contact Materials (FCMs)**.

Constituents of food contact materials that transfer from these materials into the food may affect the chemical safety of the food and affect human health, as well as the quality of the food, its taste and smell, and its appearance.

To ensure a high level of food safety, all food contact materials must comply with Regulation (EC) No 1935/2004 on materials and articles intended to come into contact with food when placed on the European market.

II. EU legislation on specific materials

In addition to the general legislation, certain FCMs — ceramic materials, regenerated cellulose film, plastics (including recycled plastic), as well as active and intelligent materials — are covered by specific EU measures.

There are also specific rules on some starting substances used to produce FCMs.

- Plastic Materials
- Active and Intelligent Materials
- Recycled Plastic Materials
- Ceramics
- Regenerated Cellulose Film

European Comission
https://food.ec.europa.eu/food-safety/chemical-safety/food-contact-materials/legislation_en

Funded by the European Union

Smart packaging: European Regulatory framework

- Regulation (EC) No 450/2009 lays down specific rules for active and intelligent materials and articles, which supplement those set out in Regulation (EC) No 1935/2004, the general regulation on materials and articles intended to come into contact with food.
- It establishes specific requirements for the marketing of these materials and articles and sets out the procedure for their authorisation at EU level.

30.5.2009 EN Official Journal of the European Union L 135/3

COMMISSION REGULATION (EC) No 450/2009

of 29 May 2009

on active and intelligent materials and articles intended to come into contact with food

(Text with EEA relevance)

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Community,

Having regard to Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC (1), and in particular Article 5(1) (h), (i), (l), (m) and (n) thereof,

substances that have to comply with Community and national provisions applicable to food and labelling rules. Specific rules should be laid down in a specific measure.

(4) This Regulation is a specific measure within the meaning of Article 5(1)(b) of Regulation (EC) No 1935/2004. This Regulation should establish the specific rules for active and intelligent materials and articles to be applied in addition to the general requirements established in Regulation (EC) No 1935/2004 for their safe use.

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R0450

European Regulatory framework

- The regulation aimed to establish an EU-wide list of substances that can be used in the manufacture of these materials: substances may only be added to the list once their safety has been evaluated for safety by EFSA.

efsa EUROPEAN FOOD SAFETY AUTHORITY

EN English

Home / All topics

Active and intelligent materials

Food contact materials (FCMs) refer to materials and articles intended to be in contact with food, such as packaging and containers, kitchen equipment, cutlery, and dishes. Some materials and articles enhance the foods they contain or give information on the condition of foods and/or the surrounding environment. These are known as active or intelligent food contact materials.

Last reviewed date: 19 September 2024

Active and intelligent packaging substances

Published

Time-temperature indicator system based on C. maltaromaticum and acid fuchsin
25 July 2013 Scientific Opinion

Iron based oxygen absorbers
12 April 2013 Scientific Opinion

Citric acid, sodium hydrogen carbonate
9 April 2013 Scientific Opinion

Sodium carbonate peroxyhydrate coated, bentonite, sodium chloride, sodium carbonate
9 April 2013 Scientific Opinion

Acrylic acid, sodium salt, co-polymer with acrylic acid, methyl ester, methacrylic acid, 2-hydroxypropylester, and acrylic acid crosslinked
9 April 2013 Scientific Opinion

Polyacrylic acid, sodium salt, crosslinked
13 February 2013 Scientific Opinion

Sodium carboxymethylcellulose, bentonite, aluminium potassium sulphate
18 October 2012 Scientific Opinion

Iron (II) modified bentonite
18 October 2012 Scientific Opinion

open-cell expanded polystyrene, talc, alkyl(C8-C22) sulphonic acid (salts)
31 May 2012 Scientific Opinion

Activated carbon, water, iron powder, kaolin calcined, sulphur, sodium chloride
28 March 2012 Scientific Opinion

https://www.efsa.europa.eu/en/topics/active-and-intelligent-materials

Funded by the European Union

Smart packaging: European Regulatory framework

DESCRIPTION OF POSITIVE EFSA SCIENTIFIC OPINIONS	BRAND, ENTERPRISE, website
time-temperature indicator system, based on the microorganism *Carnobacterium maltaromaticum* and acid fuchsin as colour change indicator	TopCryo, Cryolog SA, France http://cryolog.com/en/
Iron-based oxygen absorbers (active substances iron, sodium chloride, water, silica gel, activated carbon, monosodium glutamate, potassium acid tartrate, powdered cellulose, malic acid, chabazite, hydroxypropyl cellulose, potassium carbonate, sodium thiosulfate, propylene glycol, glycerin, polyethyleneglycol sorbitan monooleate, sodium propionate and clinoptilolite)	Multisorb Technologies, USA https://www.multisorb.com/
active substances citric acid (E330) and sodium hydrogen carbonate (E500ii), used as **carbon dioxide generators**, together with liquid absorbers cellulose and polyacrylic acid sodium salt crosslinked	McAirlaid's, Germany https://www.mcairlaids.net/en
combined oxygen generator and carbon dioxide absorber sodium carbonate peroxyhydrate coated with sodium carbonate and sodium silicate, bentonite, sodium chloride, sodium carbonate	EMCO Packaging Systems Ltd, UK http://www.emcopackaging.com/
liquid absorber in the form of fibres acrylic acid, sodium salt, co-polymer with acrylic acid, methyl ester, methacrylic acid, 2 hydroxypropylester, and acrylic acid cross-linked	Technical Absorbents Ltd. https://shop.techabsorbents.com/ https://exploresaf.com/
liquid absorber polyacrylic acid, sodium salt crosslinked	BASF SE
moisture and liquid absorber Sodium carboxy methyl cellulose, bentonite, aluminium potassium sulfate	Maxwell Chase Technologies LLC Atlanta USA.
iron (II) modified bentonite as **oxygen absorber**	NanoBioMatters Industries, S.L. https://bactiblock.com/
liquid absorber open-cell expanded polystyrene manufactured with talc and alkyl(C8-C22) sulphonic acid (salts)	Activopack®-BAT®
oxygen absorber activated carbon, water, iron powder, kaolin calcined, sulphur and sodium chloride for use as active component in food contact materials	Atmosphère Control SAS (France)
sodium borohydride and palladium acetate used in combination as an **oxygen absorbing system**	ColorMatrix Group.

Smart packaging: European Regulatory framework

Commercial exemples of Active and Intelligent Packaging in the EU

Active Packaging in the EU

- Moisture Absorbers – ProAmpac's ProActive Intelligence MP-1000 eliminates the need for desiccant sachets in food packaging.
- Ethylene Absorbers – used in fresh produce packaging (e.g., Mitsubishi Gas Chemical's Ageless) to delay ripening
- Oxygen Scavengers – used by Amcor Group GmbH in meat and dairy packaging to extend shelf life by absorbing residual oxygen.
- Antimicrobial films – Aptar CSP Technologies collaborates with brands to integrate antimicrobial agents into flexible packaging for perishable foods.

Intelligent Packaging in the EU

- Time-temperature Indicators (TTI) – Freshpoint® labels by BASF visually indicate temperature abuse in chilled products
- pH-sensitive freshness indicators – Research-backed labels (e.g., Northeast Forestry University's nano-silica film) detect spoilage in meat/seafood.
- RFID/NFC tags – Avery Dennison provides RFID solutions for real-time tracking in pharmaceuticals and food logistics.
- QR codes – Crown Holdings Inc. integrates QR codes in beverage packaging for traceability, consumer engagement and anti-counterfeiting.

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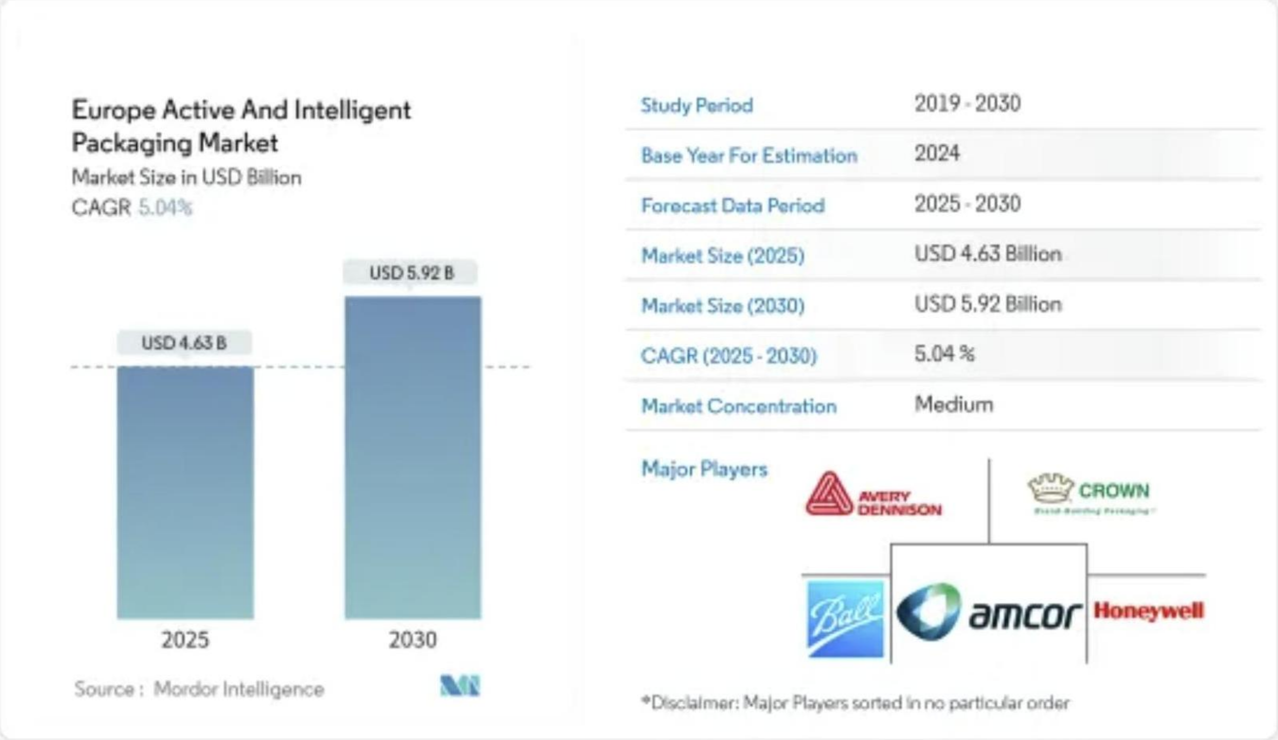
Smart packaging: European Regulatory framework

Key Market Players

- **Amcor**, **Honeywell**, and **Ball Corporation** lead in active packaging.
- **Avery Dennison** and **ProAmpac** drive intelligent packaging innovations



- These solutions comply with **EU Regulation (EC) No 450/2009**, ensuring safety and sustainability.
- The market is projected to grow to **$5.92 billion by 2030**, driven by food safety and anti-waste initiatives.

Europe Active And Intelligent Packaging - Market Share Analysis, Industry Trends & Statistics, Growth Forecasts (2025 - 2030)
https://www.giiresearch.com/report/moi1626901-europe-active-intelligent-packaging-market-share.html

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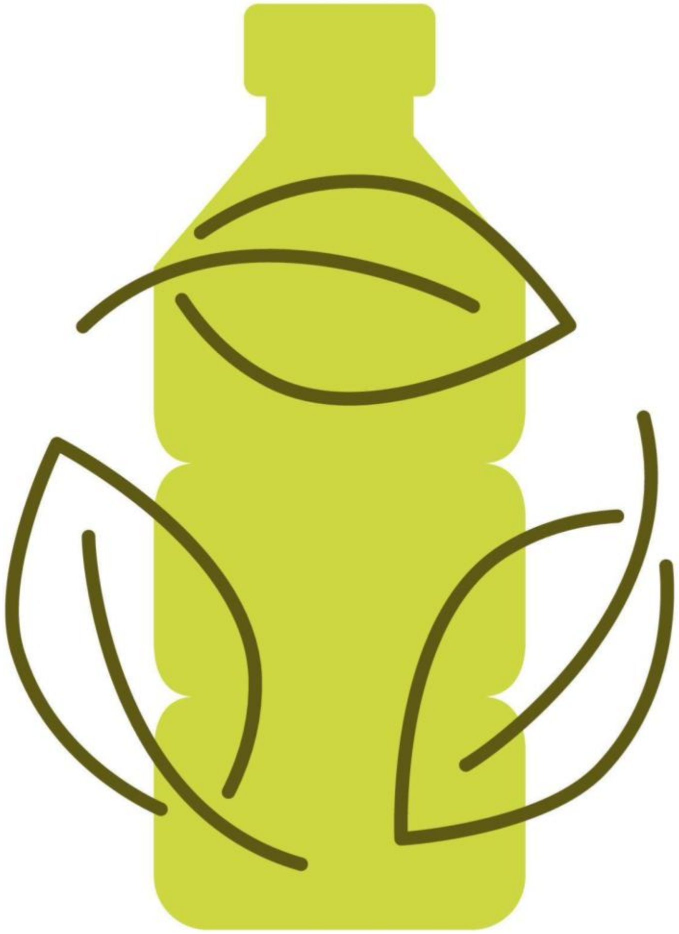
4.3.2. New Food Packaging Materials

- Environmental Impact of Packaging Waste
- Packaging waste management
- Recycled Material
- Biodegradable Material
- Edible Material (Edible Coatings)



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Environmental Impact of Packaging Waste

The Food System Life Cycle

Waste treatment

Seed production, animal feed, fertilizers, pesticides, equipment, packaging → Production → Processing → Sale → Consumption → Packaging waste management

Production → Valorization of by-products

Processing → Valorization of by-products

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Environmental Impact of Packaging Waste

- **Food packaging waste**, particularly **plastic**, is a problem that needs to be managed after food consumption.
- Environmental Impact on:
  - Pollution and ecosystem damage (marine contamination and landfill overload)
  - Climate
  - Waste of a resource
  - Human health risks

SUSTAINABLE SOLUTIONS

- Circular systems (Reusable packages, Ecodesign and Recycled materials)
- Biodegradable material
- Edible coatings

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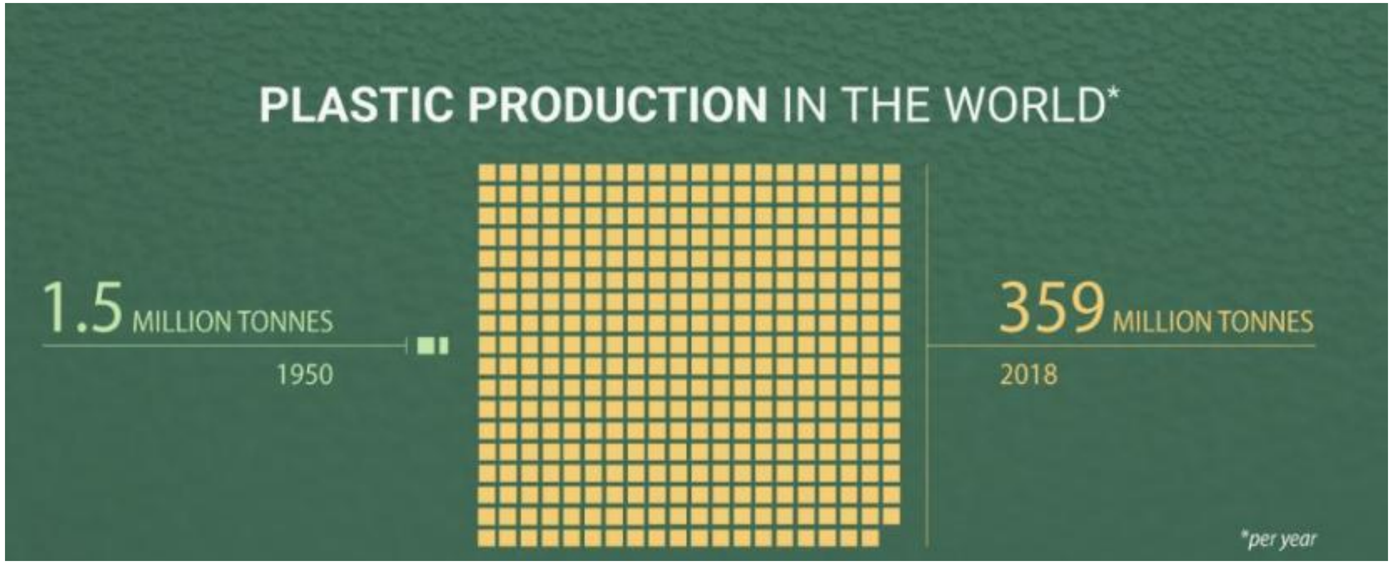
Environmental Impact of Packaging Waste

- About 22 million tonnes of plastic found its way into soils, rivers and oceans in 2019, and plastic leakage is projected to double by 2060.
- In 2019, plastics generated 1.8 billion tonnes of greenhouse gas (GHG) emissions – 3.4% of global emissions – with 90% of these emissions coming from their production and conversion from fossil fuels. By 2060, emissions from the plastics lifecycle are set to more than double, reaching 4.3 billion tonnes of GHG emissions.
- Each person living in the EU generated 36.1 kilos of **plastic packaging** waste on average in 2021. The volume of plastic packaging waste generated per inhabitant **increased by about 29%** (+8.1 kilos per person) between 2010 and 2021.



Source: https://www.europarl.europa.eu/topics/en/article/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures

Environmental Impact of Packaging Waste

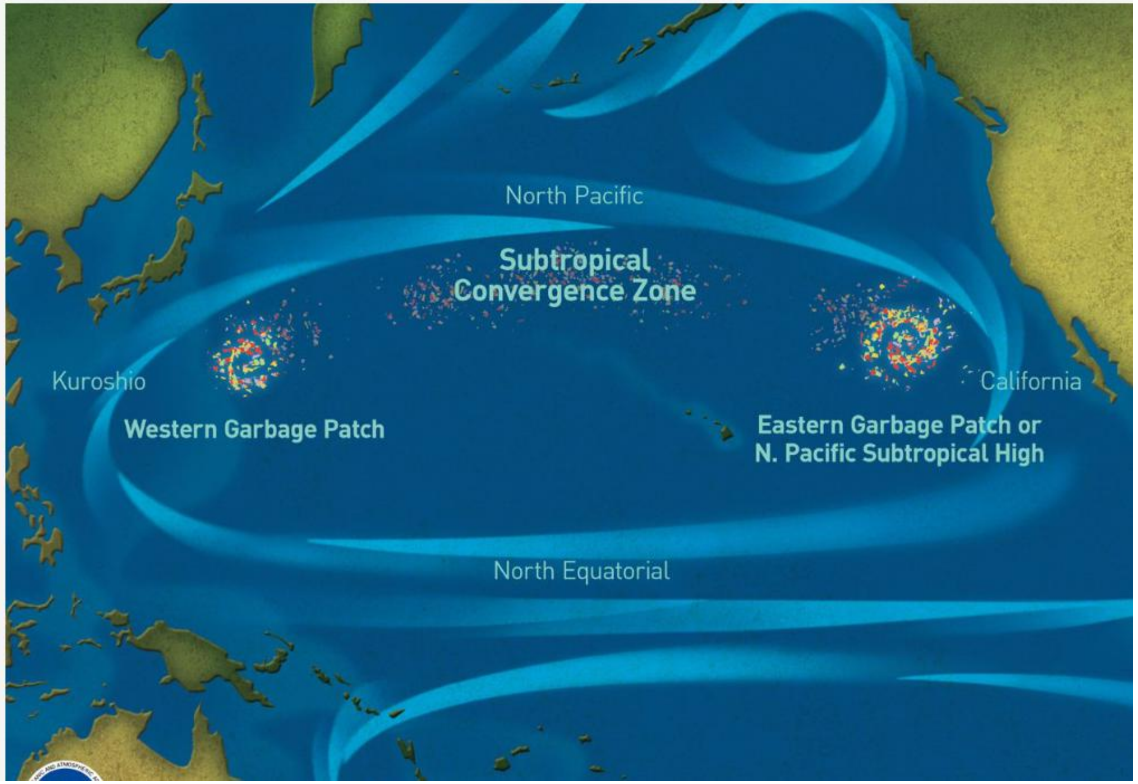
NATIONAL GEOGRAPHIC

IMPACT | **EDUCATION** | EVENTS | FUNDING OPPORTUNITIES

Great Pacific Garbage Patch

The Great Pacific Garbage Patch is a collection of marine debris in the North Pacific Ocean. Also known as the Pacific trash vortex, the garbage patch is actually two distinct collections of debris bounded by the massive North Pacific Subtropical Gyre.

MAP BY NOAA

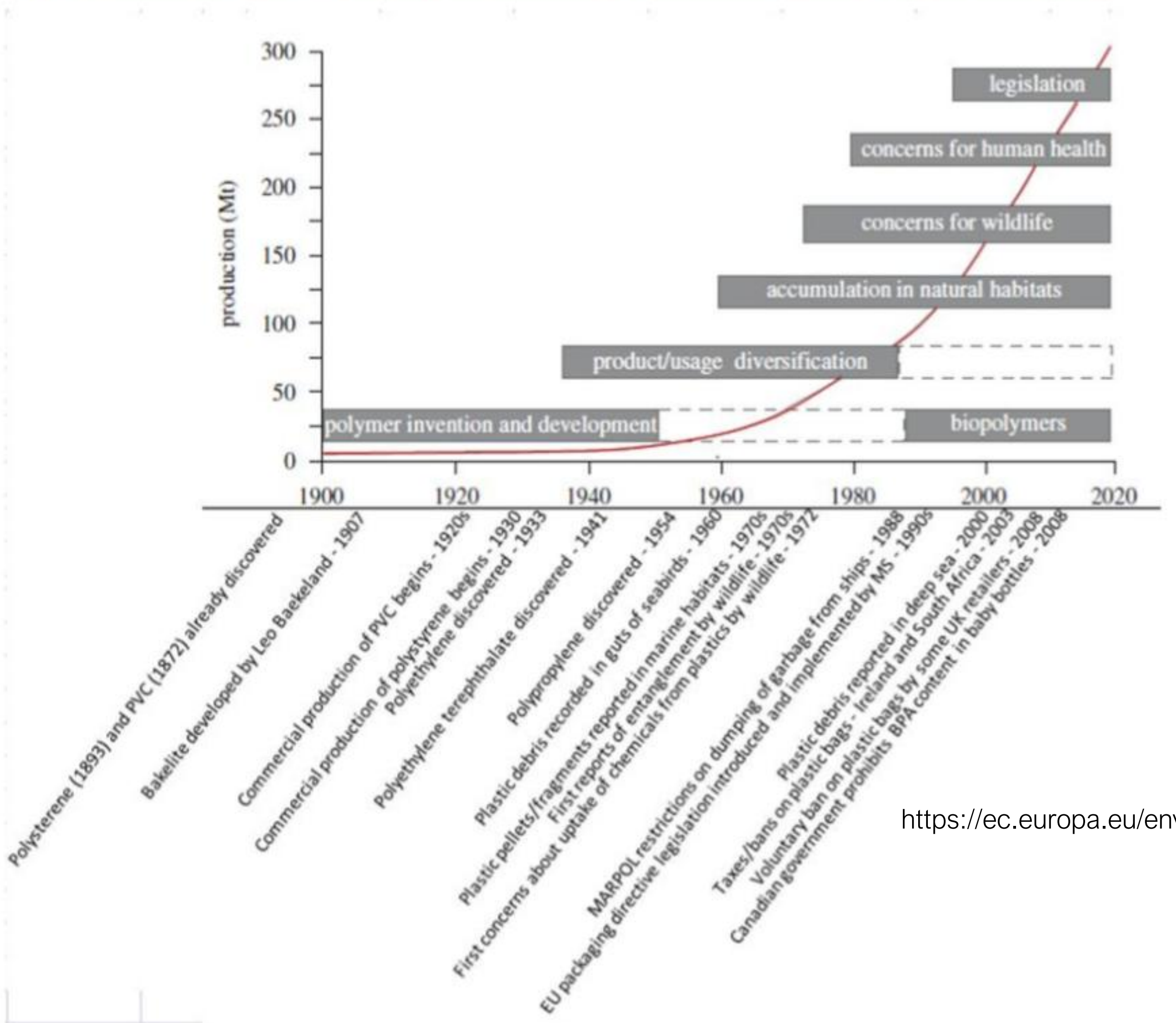


https://www.nationalgeographic.org/encyclopedia/great-pacific-garbage-patch/

Funded by the European Union

Environmental Impact of Packaging Waste

Figure 1-1: Global plastic production (Mt) with historical stages in the development, production and use of plastics, and associated concerns and legislative measures[4]

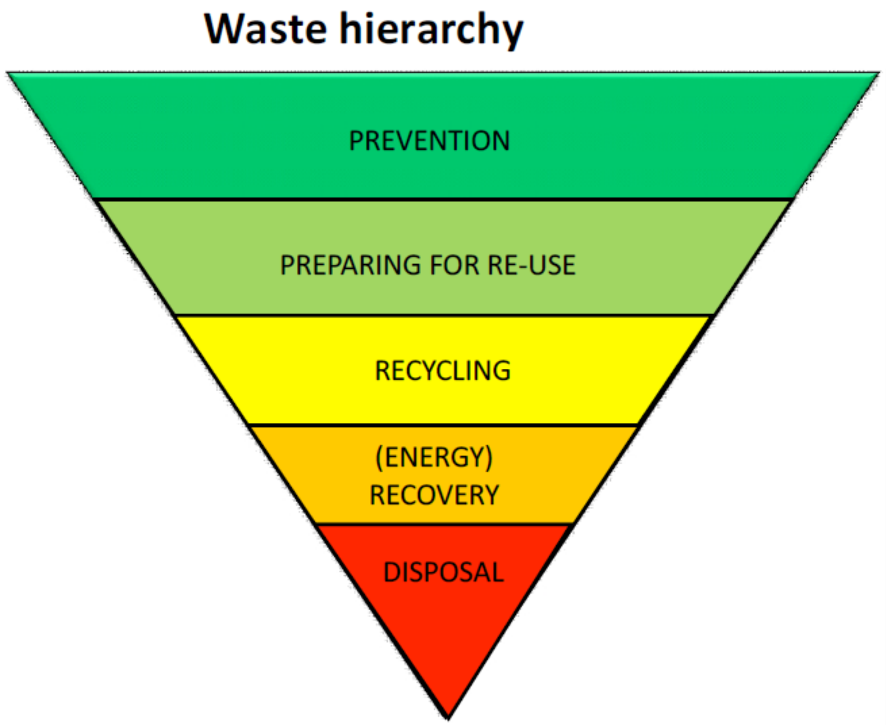


https://ec.europa.eu/environment/waste/studies/pdf/plastics.pdf

Packaging Waste Management

Waste Policy

- Reduced consumption (prevention)
  - Sensitisation
  - Legislation
- Packaging Waste Recovery Processes
  - Reuse
  - Recycling
    - Mechanical Recycling
    - Organic Recycling
  - Incineration
- Landfill



Source: European Commission
https://www.europarl.europa.eu/EPRS/EPRS-Briefing-573936-Circular-economy-package-FINAL.pdf

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Packaging Waste Management

Recycling Processes are extremely important in the circular economy, by transforming packaging waste into valuable resources while minimizing environmental harm.

Source: European Commission
https://ec.europa.eu/jrc/en/news/research-helps-europe-advance-towards-circular-economy

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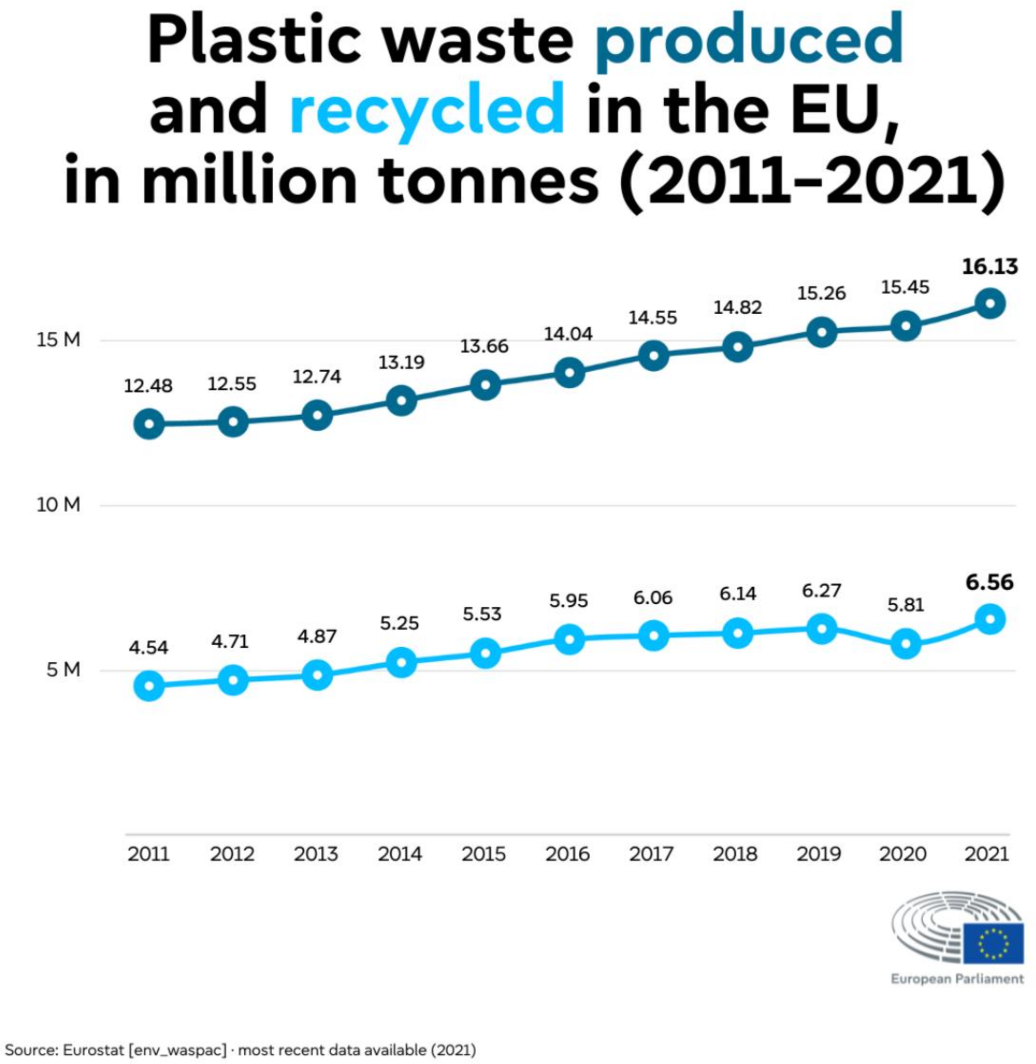
Recycled Material



In 2022, a total of 83.4 million tonnes of packaging waste was produced in the EU, or 186.5 kg per inhabitant. Compared with 2021, this represents a decrease of 3.6 kg per inhabitant, but an increase of 31.7 kg compared with 2012.

Out of all the packaging waste generated in the EU, 41% were paper and cardboard, 19% was plastic, 19% glass, 16% wood and 5% metal.

In 2022, an average of 36.1 kg of plastic packaging waste was generated for each person living in the EU and out of this, 14.7 kg were recycled. Between 2012 and 2022, the amount of generated plastic packaging waste increased by 7.6 kg per capita, while the recycled amount increased by 4.0 kg.

Source: https://www.europarl.europa.eu/topics/en/article/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures

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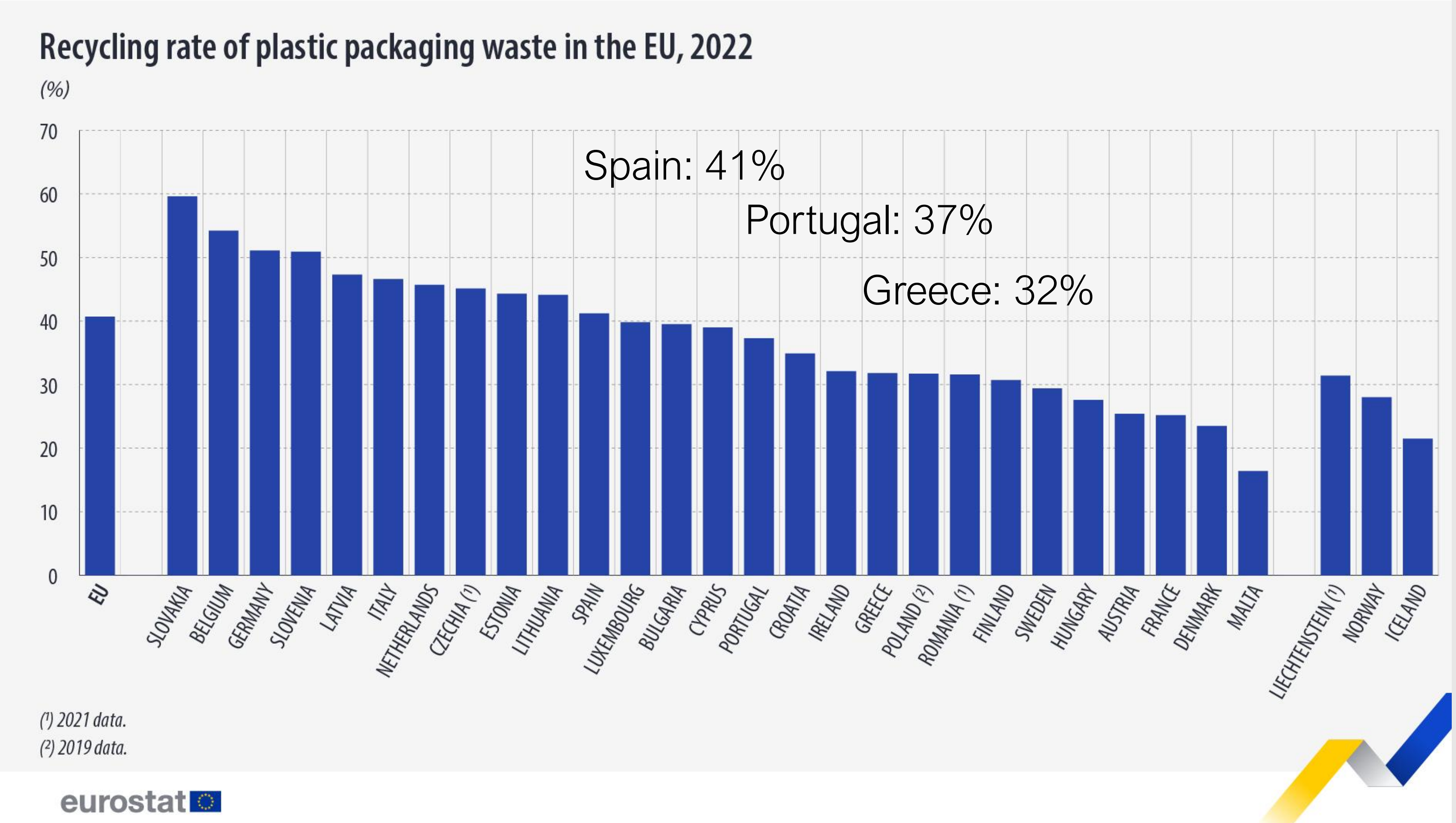
Recycled Material



Source: Eurostat https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20241024-3

In 2022, the EU recycled 41% of all the generated plastic packaging waste, indicating a slight increase compared with 2012 when the rate stood at 38%.

Slovakia recorded the highest recycling rate at 60%, followed by Belgium (54%), Germany and Slovenia (both 51%).

In contrast, the lowest rates were recorded in Malta, where 16% of the plastic packaging waste was recycled, followed by Denmark (23%), France and Austria (both 25%).

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Recycled Material

Commission Regulation (EU) No 10/2011 sets out criteria for the composition of new plastic materials.
However after these materials have been used, they do not comply anymore to the plastic Regulation, as they may have been contaminated with other substances. Therefore, a separate Regulation exists to control the recycling processes: Commission Regulation (EU) 2022/1616 on recycled plastic materials and articles intended to come into contact with foods.

20.9.2022 EN Official Journal of the European Union L 243/3

COMMISSION REGULATION (EU) 2022/1616

of 15 September 2022

on recycled plastic materials and articles intended to come into contact with foods, and repealing Regulation (EC) No 282/2008

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC ([1]), and in particular Article 5(1), second subparagraph, points (h), (i), (k) and (n), thereof,

https://food.ec.europa.eu/food-safety/chemical-safety/food-contact-materials/legislation_en#recycled_plastic_material
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1616

Recycled Material

Key Challenges of Recycled Food Packaging Materials

- Contamination Risks
  - Food residues in used packaging can compromise recyclability, requiring thorough cleaning that increases costs and energy use.
  - Chemical contaminants (e.g., dyes, stabilizers) from non-food-grade plastics may migrate into food, raising safety concerns.
- Material Complexity
  - Multi-layer plastics are difficult to separate into pure streams, reducing recycling efficiency.
  - Mixed-material packaging (e.g., paper-lined with plastic coatings) often ends up in landfills due to processing challenges.
- Regulatory and Safety Barriers
  - Strict food-contact regulations limit use of recycled plastics in direct food packaging due to potential chemical migration.
  - Lack of harmonized standards globally complicates compliance for manufacturers.
- Economic and Logistical Issues
  - High processing costs for sorting, cleaning, and decontaminating recycled materials deter investment.
  - Inconsistent collection systems in many regions lead to low recycling rates (~44% for plastics in the EU).
- Performance limitations
  - Recycled materials may have reduced durability or barrier properties compared to virgin plastics, limiting applications.
  - Thermal degradation during recycling can weaken polymers, restricting reuse in high-performance packaging.
- Consumer Perception
  - Misconceptions about hygiene and quality of recycled packaging hinder market acceptance.

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Recycled Material

INNOVATIONS ADRESSING THESE CHALLENGES

- Chemical recycling
  - Breaks down complex plastics into reusable monomers.
- Functional barriers
  - Layers of virgin plastic shield food from recycled material contaminants.
- Smart sorting technologies
  - AI and optical sensors improve separation accuracy.

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Biodegradable Material

Funded by the European Union

Biodegradable Material

Biodegradable material is the material that is degraded by the enzymatic action of bacteria and/or fungi, which can be compostable and has great potential to replace plastics based on petrochemical derivatives.

Compostable: Compostability describes the property of being biodegradable under industrial or home composting conditions.

- They have short degradation time (weeks) compared to "non-degradable".
- Conventional plastics are not biodegradable due to their long chain of molecules, which is complex and large enough to inhibit microbial degradation.
- Oxodegradable material is different from biodegradable material:
  - Oxo-degradable material has additives that accelerate the degradation process;
  - However, it raises environmental problems: as they fragment into small pieces, they contribute to microplastic pollution, becoming a risk to oceans and other ecosystems.

Funded by the European Union

Biodegradable Material

Sources

- Biodegradable materials for food packaging can come from **renewable sources**, such as plants, microorganisms, and agricultural and agro-industrial or **non-renewable waste** (petrochemical derivatives).

Bio-based materials (from renewable sources) ≠ biodegradable materials

- Biomaterials is a more general term that includes, non-biodegradable biobased materials, biodegradable fossil-based materials, and biodegradable biobased materials.
- Biodegradable materials from renewable sources:
  - Natural - starch, cellulose, alginate, gum, galactoman, protein,
  - Synthetic - polyhydroxyalkanoate (PHA), polylactic acid (PLA), polybutylene succinate(PBS).
- Biodegradable materials from non-renewable sources: polycaprolactone (PCL), polybutylene adipate terephthalate (PBAT).
- Non-biodegradable materials from renewable sources: bio-based polyetheylene (PE), bio-based polypropylene (PP), or bio-based polyethylene terephthalate (PET) and technical performance polymers, such as numerous bio-based polyamides (PA), polytrimethylene terephthalate (PTT) or totally new polymers, such as polyethylene furanoate (PEF).

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FOOD INNOVATION AND THE CONSUMER

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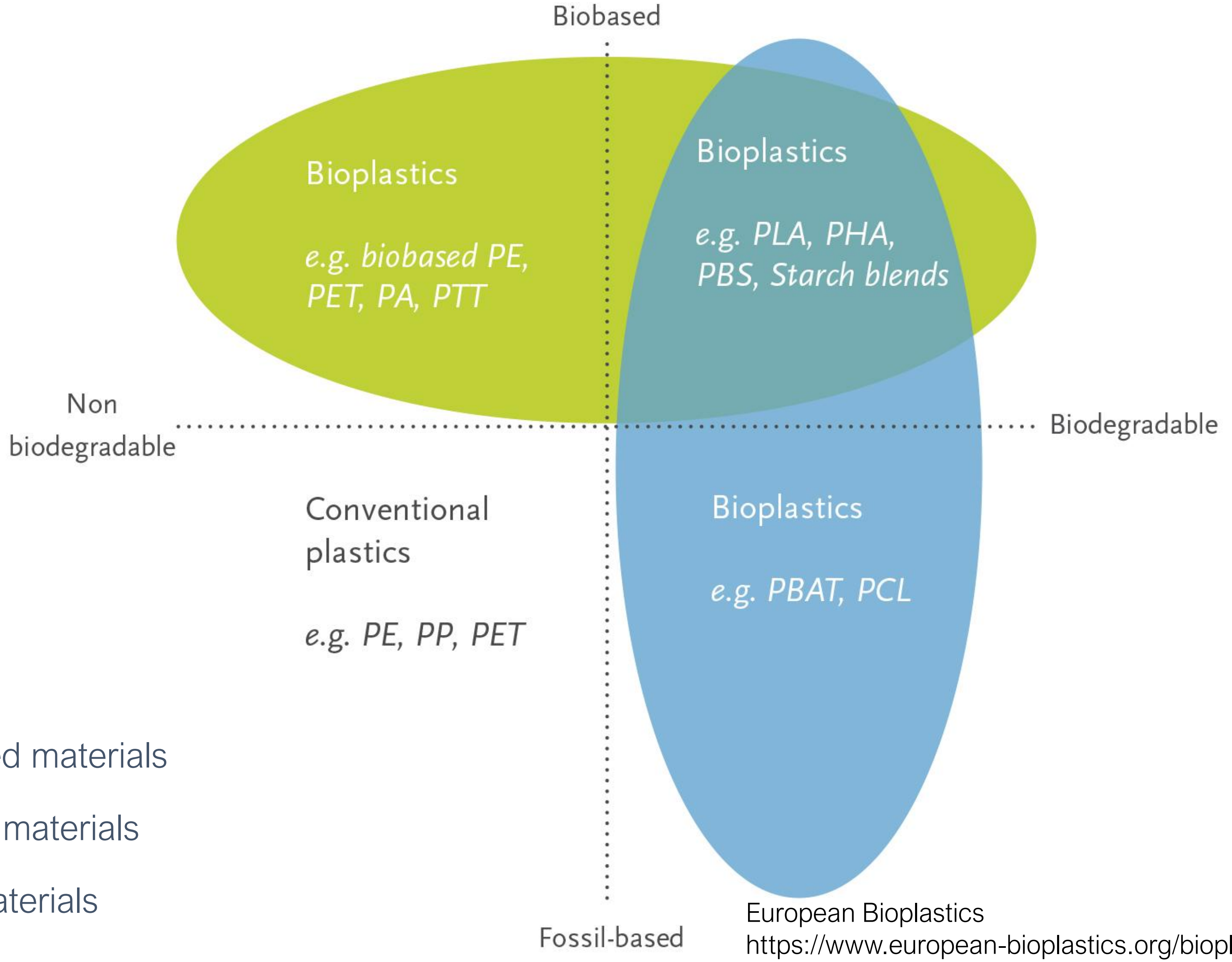
Biodegradable Material

Biomaterials or bioplastics



European Bioplastics
https://www.european-bioplastics.org/bioplastics/

- Bioplastics can be:
  - Non biodegradable **bio**based materials
  - **Bio**degradable fossil-based materials
  - **Bio**degradable **bio**based materials

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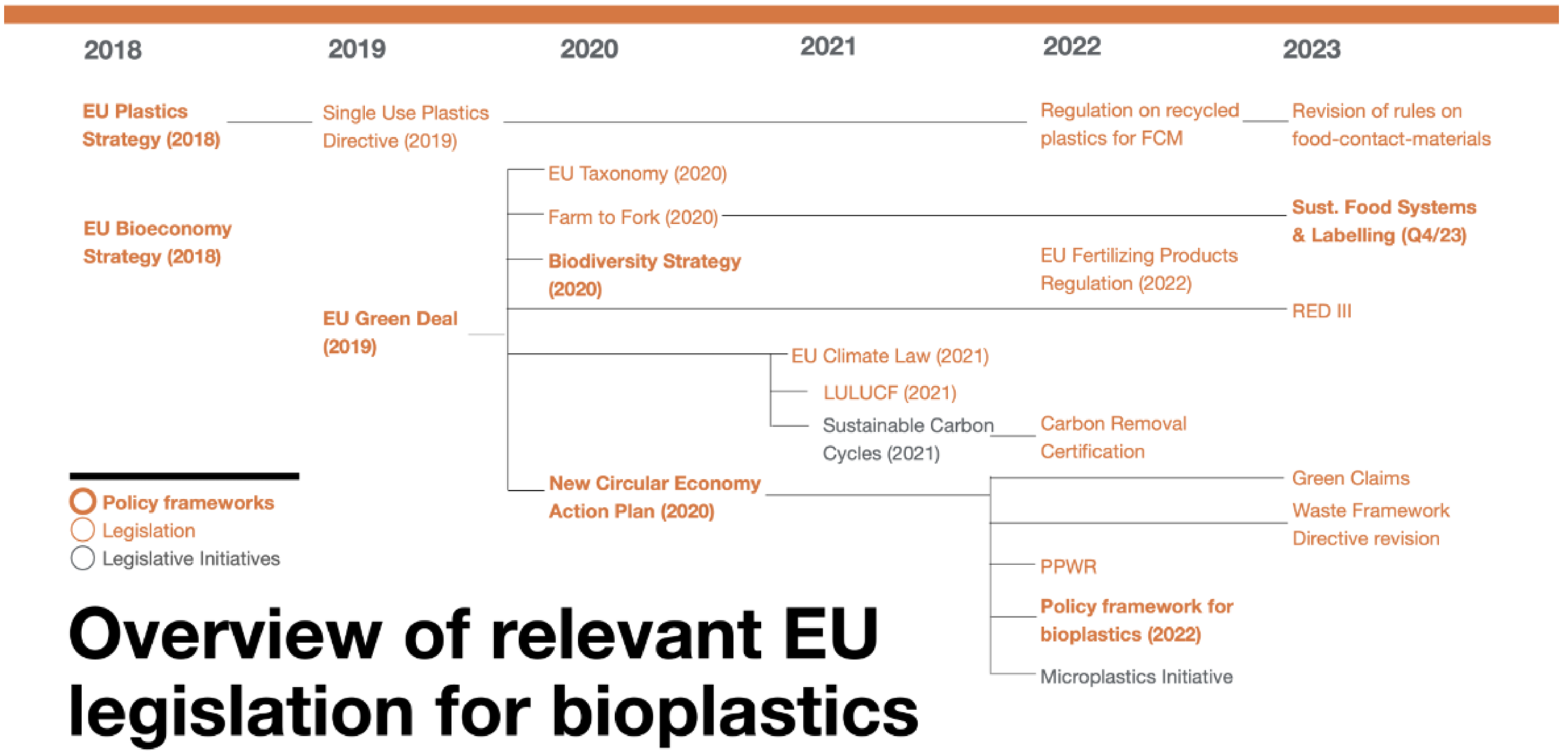
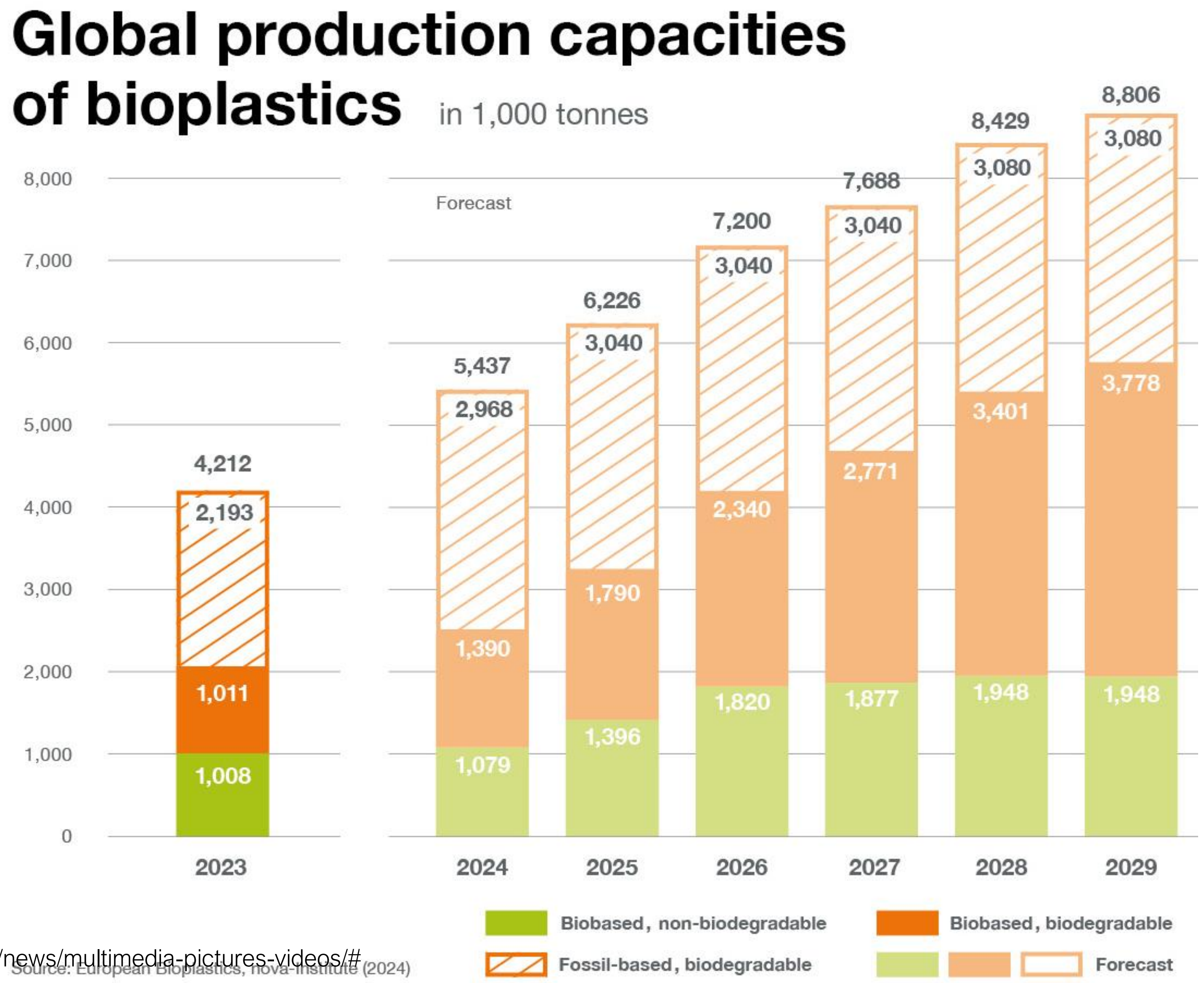
Biodegradable Material



European Bioplastics
https://www.european-bioplastics.org/bioplastics/

Biodegradable Material



European Bioplastics
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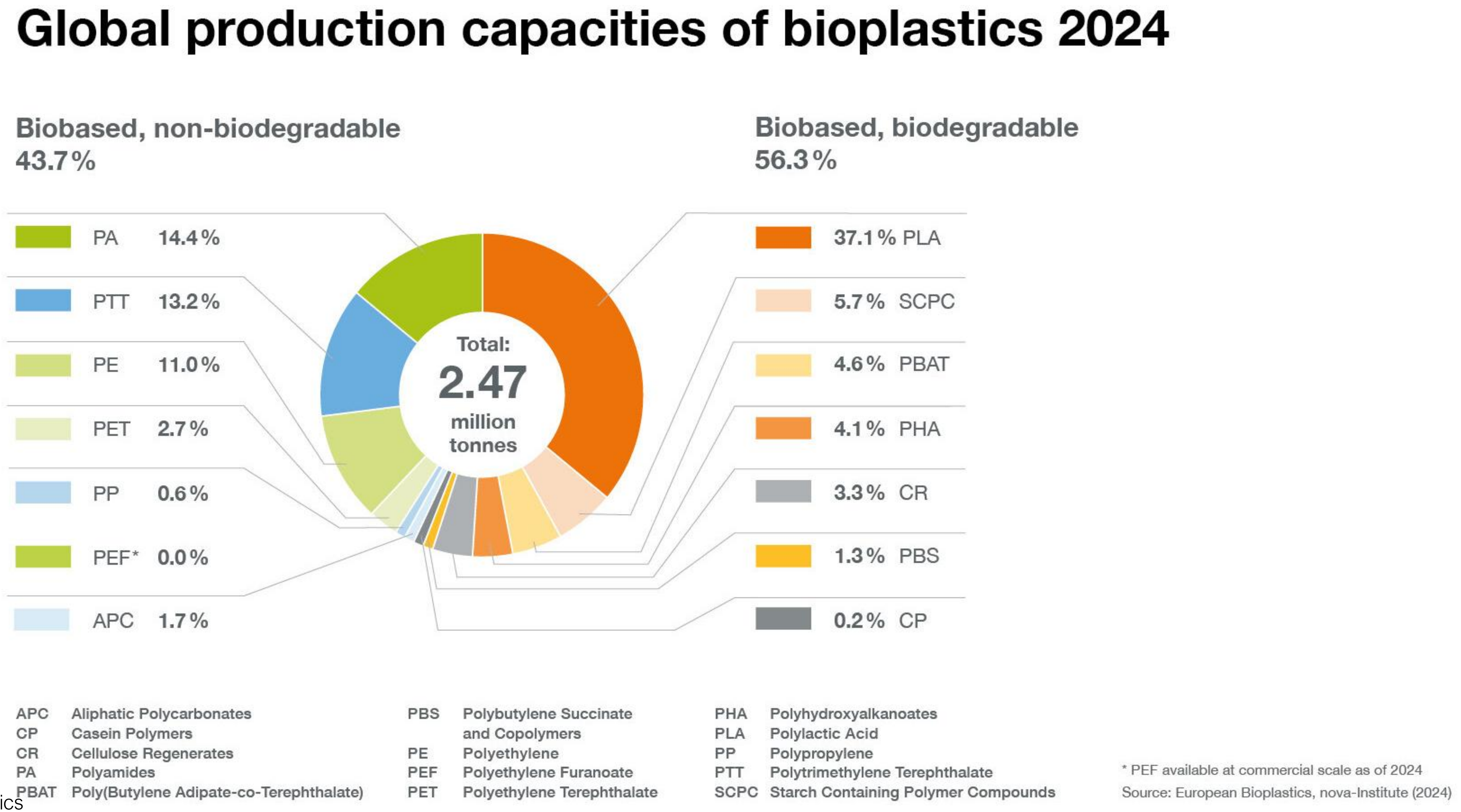
Funded by the European Union

Biodegradable Material



European Bioplastics
https://www.european-bioplastics.org/news/multimedia-pictures-videos/#

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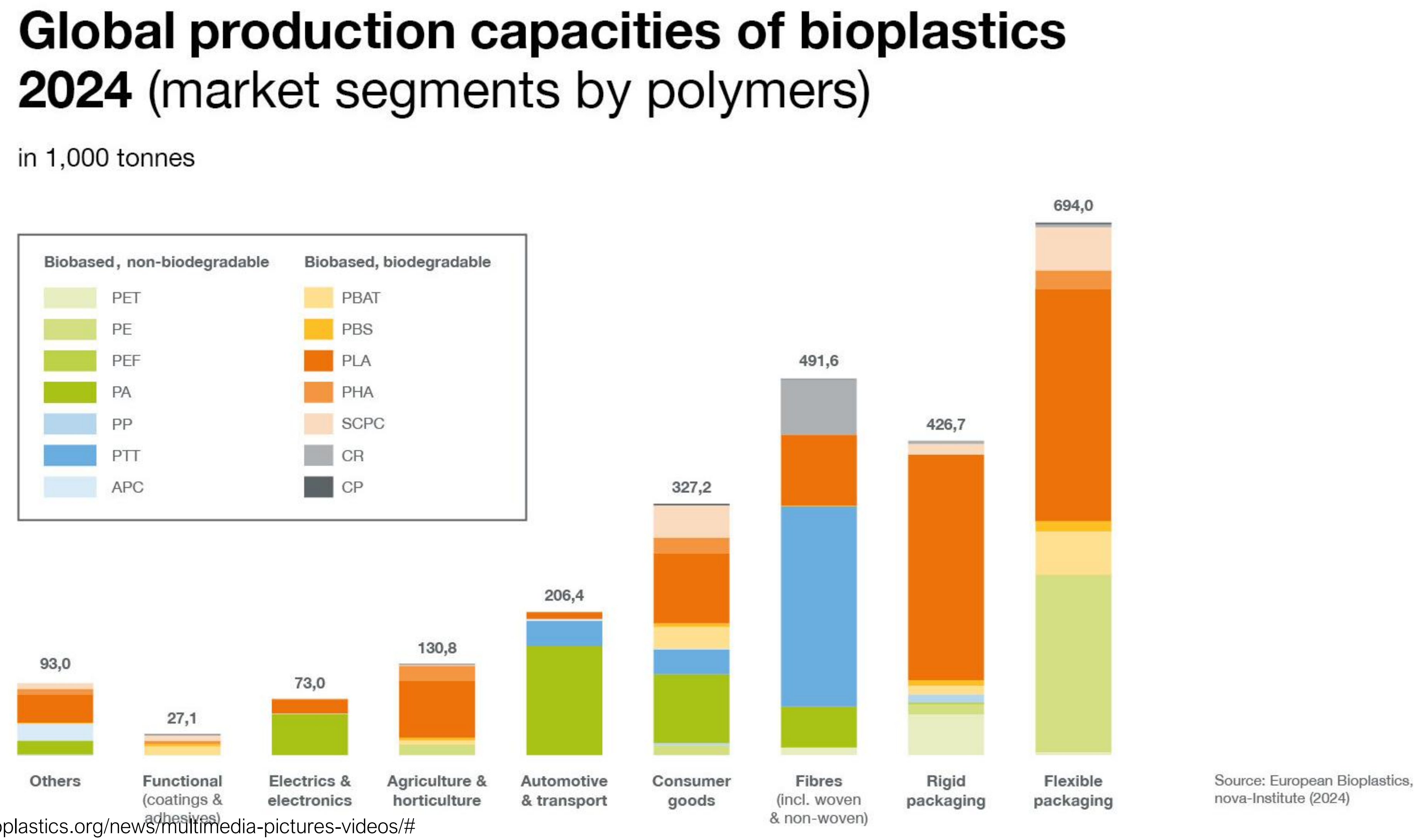
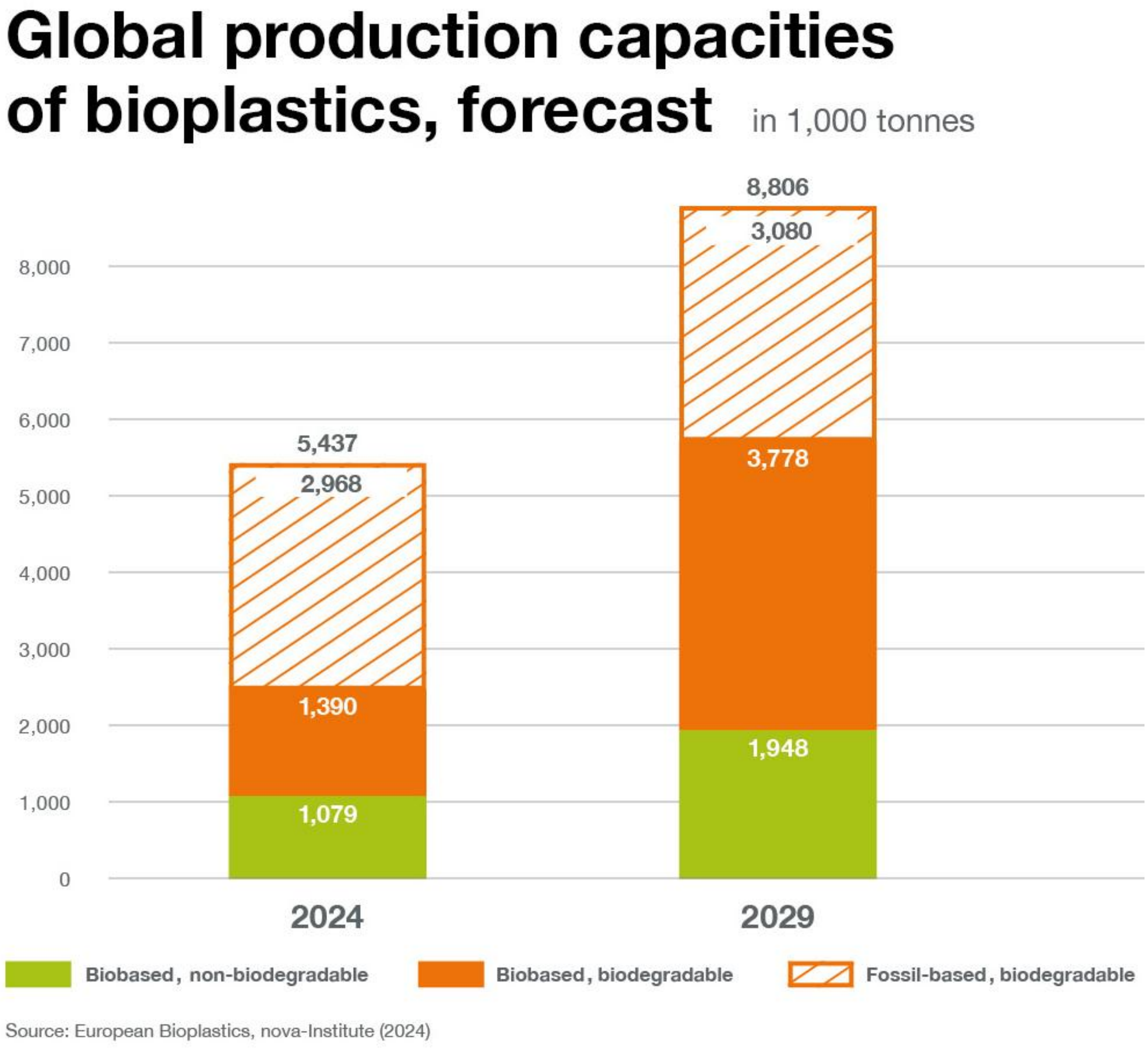
Biodegradable Material



European Bioplastics
https://www.european-bioplastics.org/news/multimedia-pictures-videos/#

Biodegradable Material



European Bioplastics
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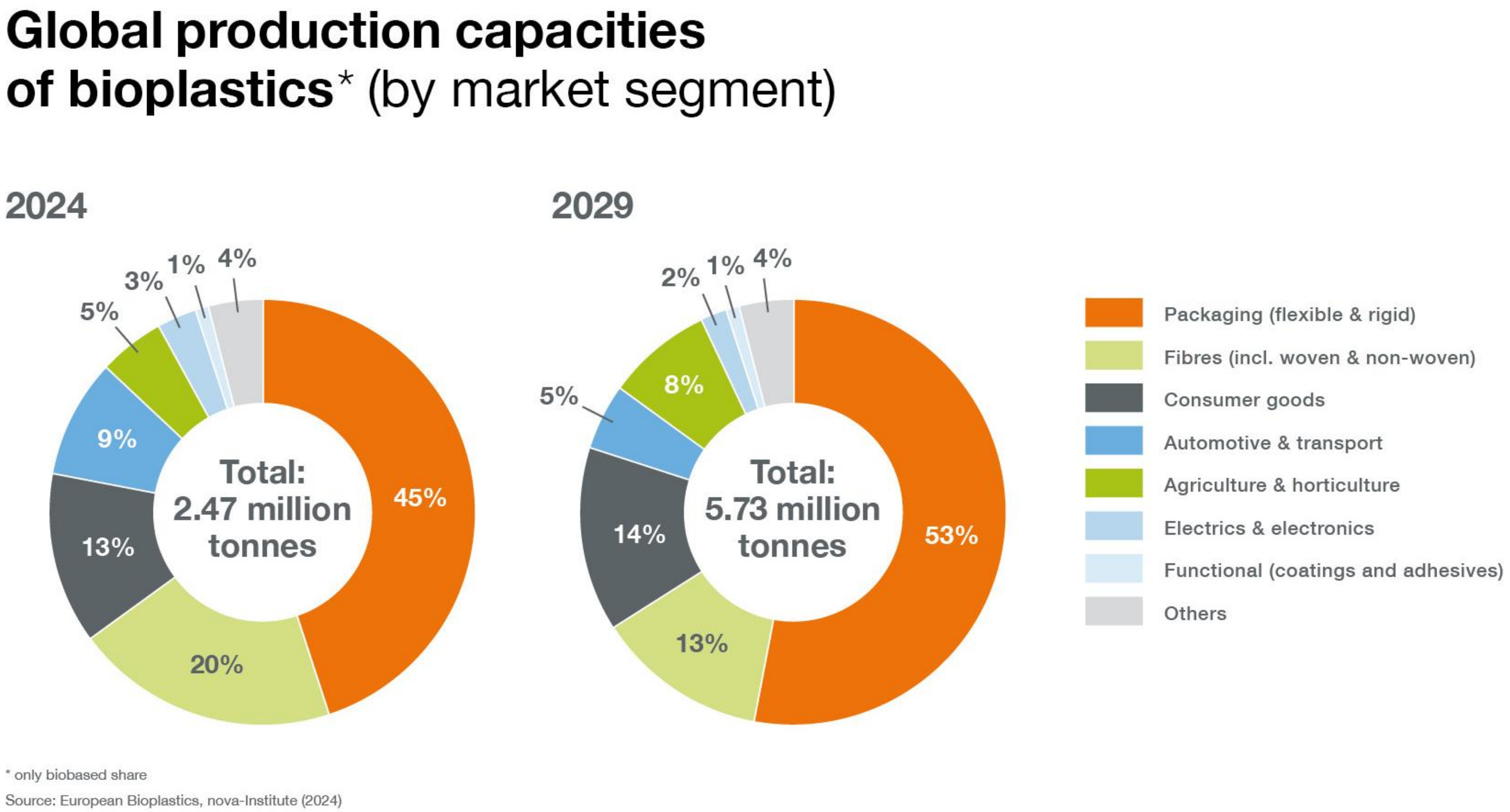
Biodegradable Material



European Bioplastics
https://www.european-bioplastics.org/news/multimedia-pictures-videos/#

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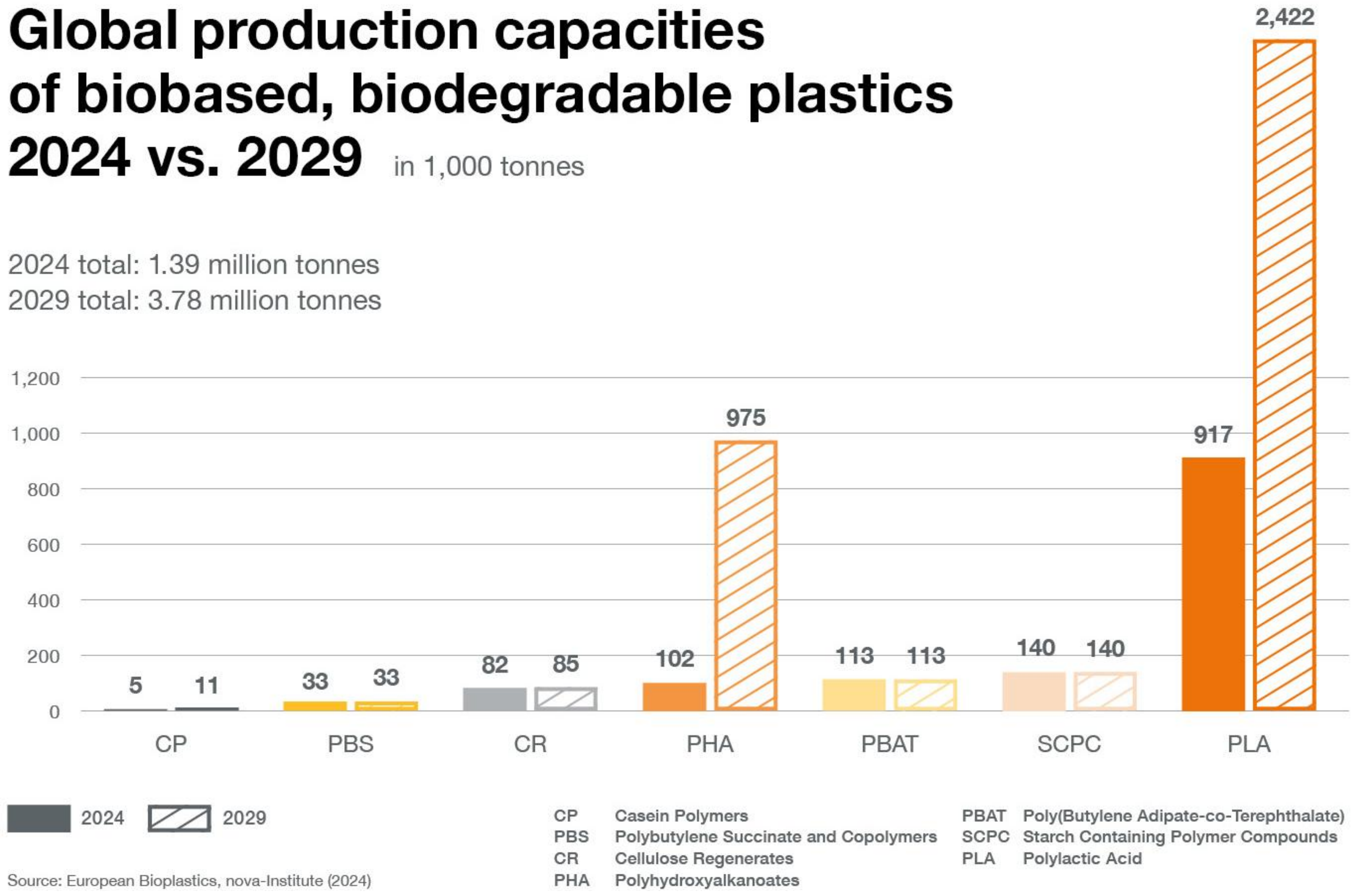
Biodegradable Material



European Bioplastics
https://www.european-bioplastics.org/news/multimedia-pictures-videos/#

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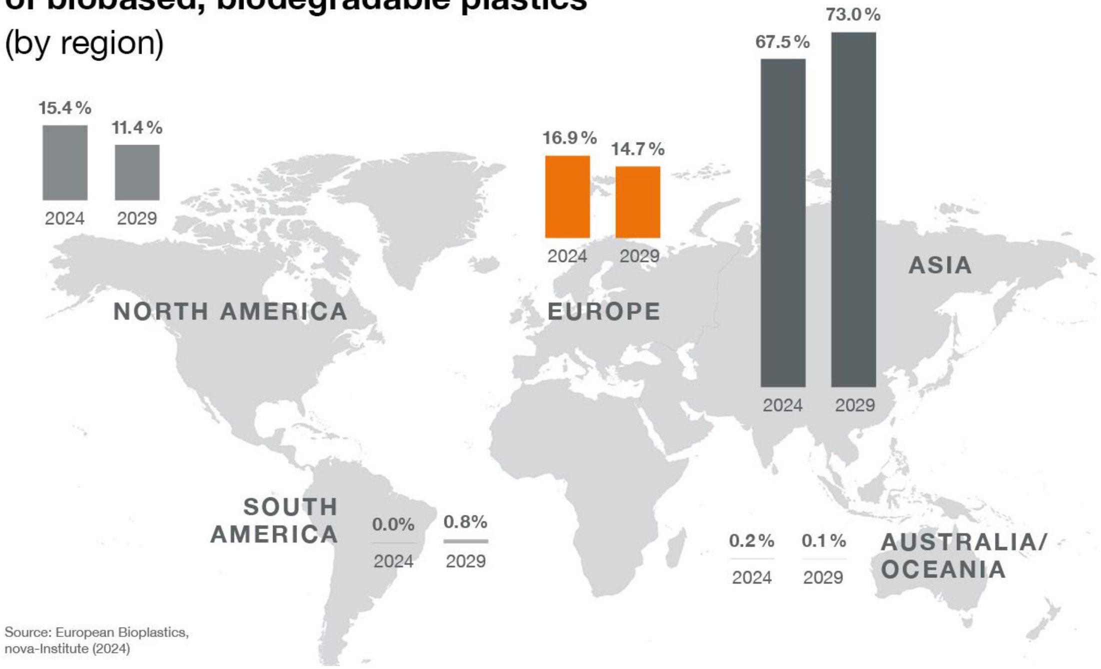
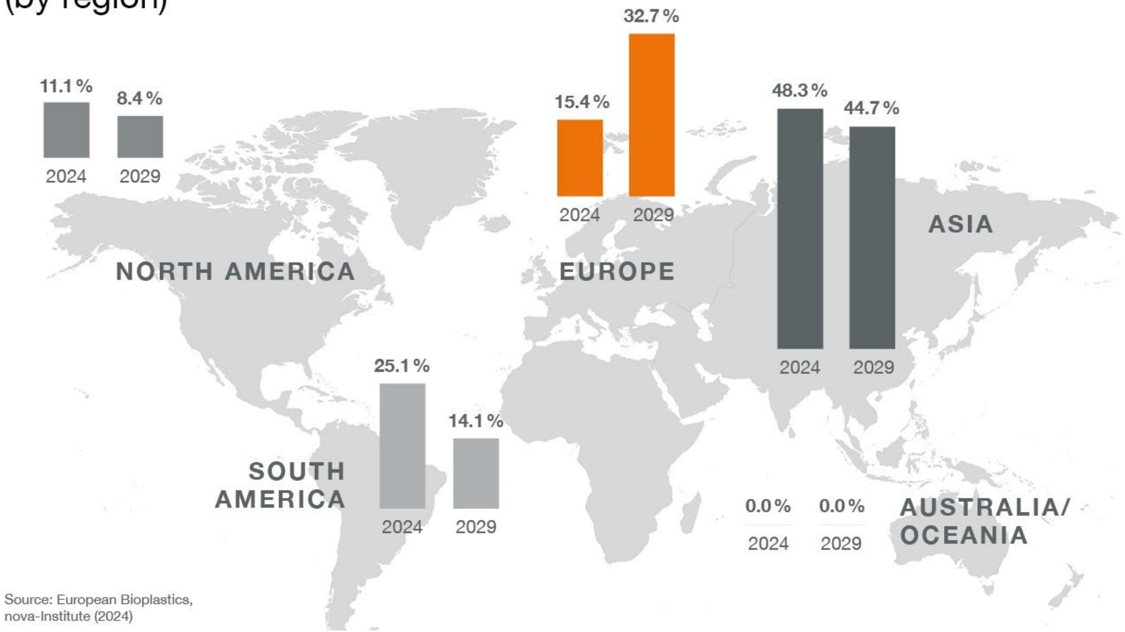
Biodegradable Material

Global production capacities
of biobased, biodegradable plastics
(by region)



Global production capacities
of biobased, non-biodegradable plastics
(by region)



European Bioplastics
https://www.european-bioplastics.org/news/multimedia-pictures-videos/#

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HELLENIC REPUBLIC National and Kapodistrian University of Athens
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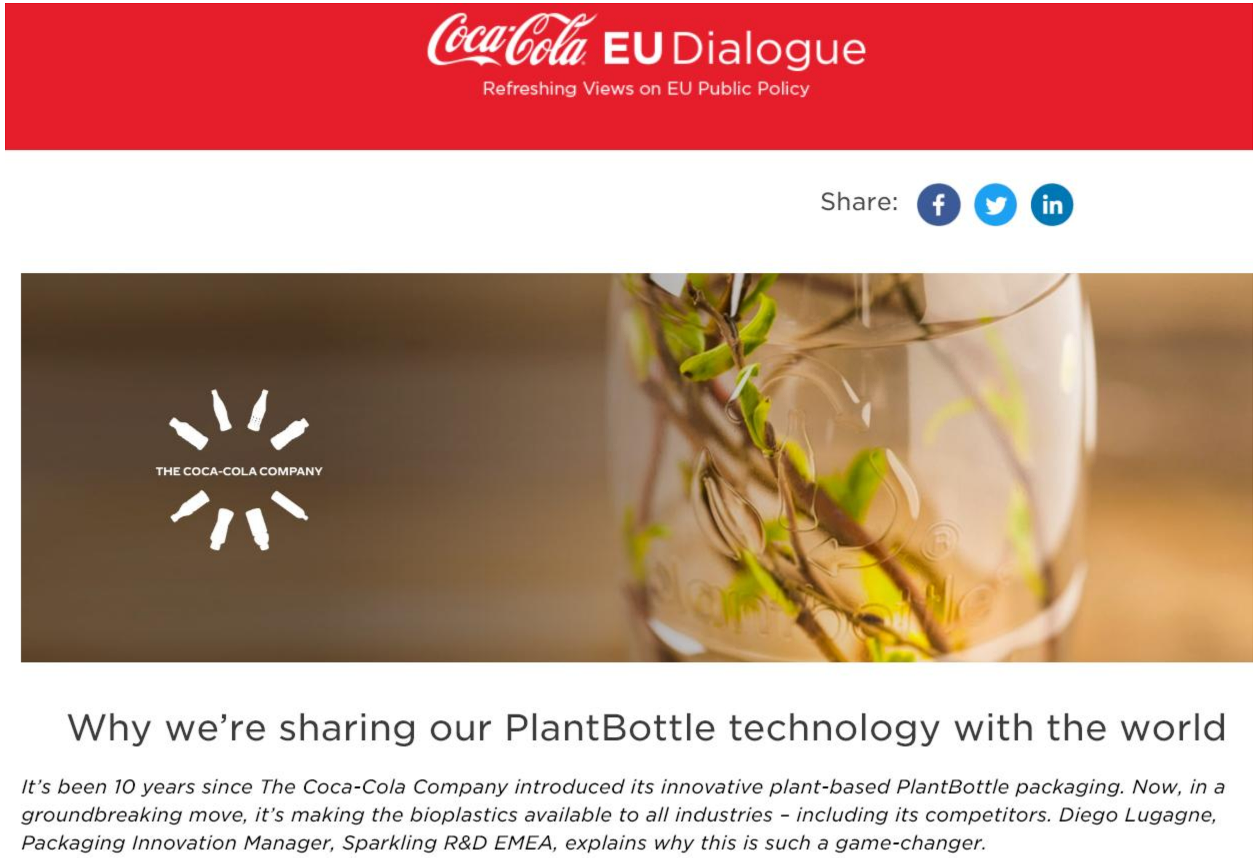
Biodegradable Material

Examples of Biobased Materials

- PlantBottle, bio-PET

  Coca Cola (2009)



Video: PlantBottle Innovation: An Interview with Diego Lugagne
https://www.youtube.com/watch?v=ph2I8R86ajQ&feature=emb_logo

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Biodegradable Material

EXAMPLES OF BIOBASED MATERIALS

- PlantBottle, bio-PET

  Heinz (2012)

BIOPLASTICS ▾ PACKAGING FEATURED APPLICATIONS PATENTS

Heinz Ketchup PlantBottles goes to Canada

Thursday, April 26, 2012 *Packaging , Plant bottle* *No comments :*

The distribution of Heinz' new plant-based Tomato Ketchup bottles across North America continues, with Canada now involved.

Unveiled in February 2011, Heinz' PlantBottle packaging was rolled out across the US in a big way last year and now, on the eve of Earth Day 2012, the firm's Canadian division has renewed its eco-friendly credentials by highlighting the design's environmentally-beneficial attributes.

http://naturalplastics.blogspot.com/2012/04/heinz-ketchup-plantbottles-goes-to.html

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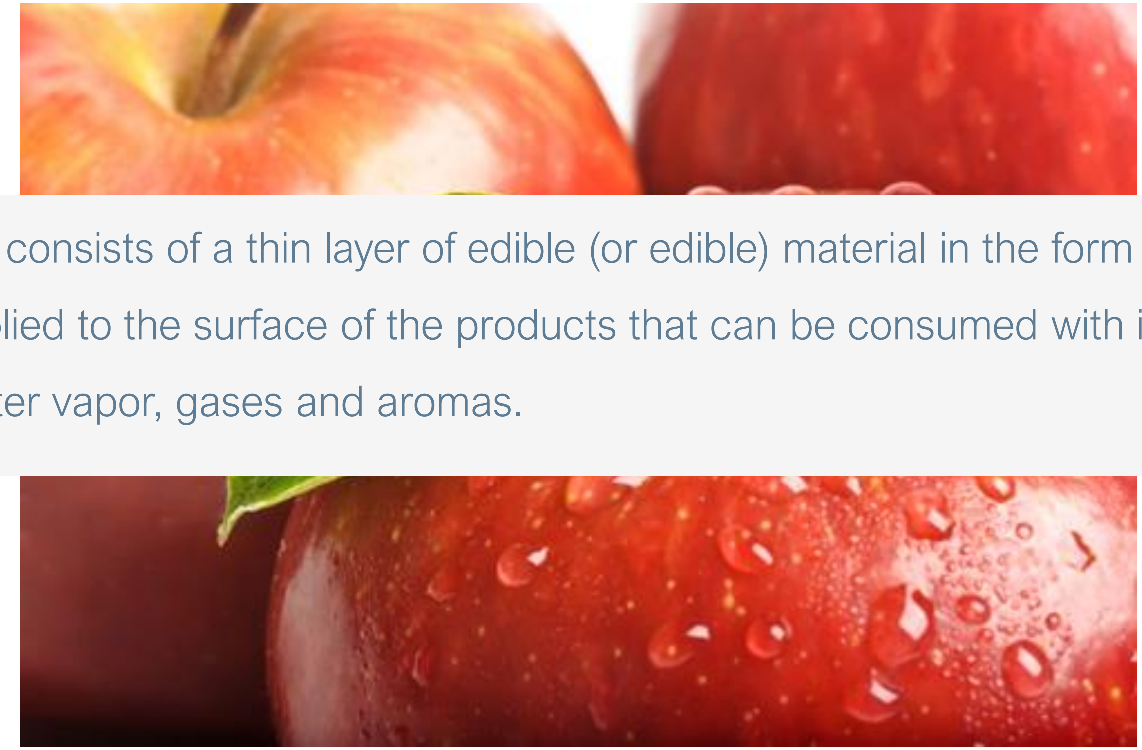
Edible coatings



Definition

Edible coating is a technology that consists of a thin layer of edible (or edible) material in the form of a suspension or emulsion that is applied to the surface of the products that can be consumed with it, and that serves as a selective barrier to water vapor, gases and aromas.

Objetive

- Reduction of senescence and deterioration (browning) of the product reduction of respiration rate, reduction of water loss, reduction of loss of volatile aromatic compounds, increase of microbiological safety, maintenance of its quality and consequent extension of the product's shelf life.

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Edible coatings

BENEFITS

- **Preservation** (increase product shelf life).
- **Fully biodegradable and compostable**
- **More environmentally friendly technology.** As edible coatings already have the function of preserving the product, the packaging does not need to have it, and more degradable/reusable/recyclable materials (e.g. paper) can be used, as an alternative to packaging made of synthetic plastic materials.
- **Replace plastic packaging; often derived from agro-industrial waste (e.g., fruit peels, whey).**
- Can **incorporate active ingredients**, such as probiotics, nutrients (vitamins, ...), spices, antimicrobial compounds, anti-browning agents, colorants and flavors, with additional specific functions according to the ingredient incorporated in the coating matrix.

"The packaging is edible but the contents aren't."

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Edible coatings

REQUIREMENTS

- Ability to maintain/improve the appearance of the product, maintain its structural integrity, maintain/improve mechanical properties, retain volatile odor compounds and transport active compounds (such as antioxidants and vitamins);
- Avoid O_2 depletion and excess CO_2 accumulation in respirating products, so as to avoid switching from aerobic to anaerobic respiration;
- It must not interfere with the original quality and appearance of the product, nor introduce any type of physiological disorder into the product or negative alteration in the original taste or odor;
- Keep intact and coat the entire product properly;
- It should be water-resistant and tolerate light pressures, and be resistant to shock and abrasion, so as to protect the structure of the food;
- It must have a good adhesion, so as to avoid its easy removal during handling, and it must be flexible, so that it can adapt to the possible deformation of the food without breaking;
- Melting above 40 °C without decomposing, it must be easily emulsifiable, non-sticky, low-viscous and have efficient drying performance, while being economical.

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Edible coatings

LIMITATIONS

- Mechanical and sensory properties of the product may be affected
- Higher cost
- High availability of synthetic polymers in the market (considering plastic packaging as an alternative to edible coating)
- Synthetic polymers have better properties:
  - Transparency
  - Good mechanical properties (stress and deformation at break);
  - Good barrier properties (water vapour, O_2, CO_2, aromas);
  - Closure (good ability to heat seal and form bag).

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Edible coatings

APPLICATIONS

- Fruits and Fresh-cut fruits (Apples, Avocados, Melons, Grapefruit, Lemons, Limes, Melons, Oranges, Passion fruit, Passion fruit, Peaches, Pineapple, ...)
- Vegetables (Cucumbers, Eggplant, Bell Peppers, Turnips, Pumpkins, Zucchini, Sweet Potato, Tomatoes, ...)
- Dairy/Cheese
- Meat
- Shellfish
- Nuts

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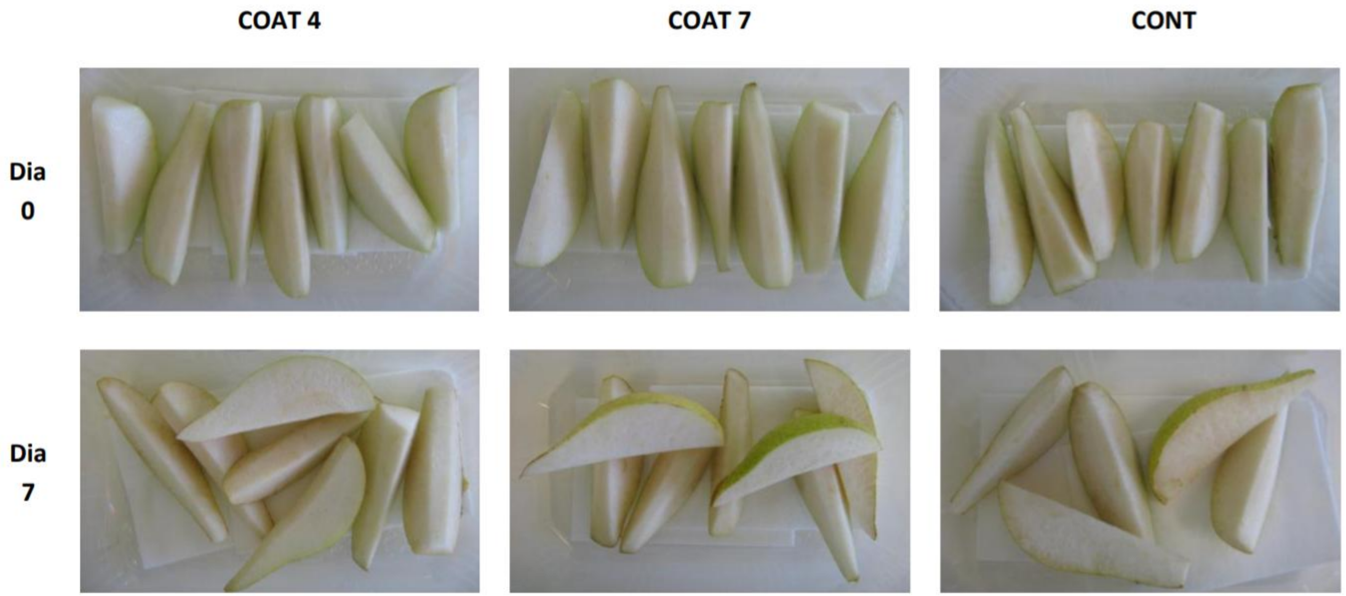
Edible coatings

APPLICATIONS



"Rocha" pear coated with sodium alginate (1%) and 1% AA (COAT 4) and 1.75% (COAT 7) and immersed in water (CONT) at 0 and 7 days of storage at 5 ºC

The coating consists of 1% sodium alginate as a hydrocolloidal agent, 1-1.75% ascorbic acid due to its antioxidant power, and glycerol at 5.25-6% with plasticizer function.

Edible coatings

APPLICATIONS

Apeel: Plant-derived coatings for avocados and citrus.

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Edible coatings

PRINCIPLE

- It acts by:
  - i) reducing the transfer of water vapor and solutes (volatile compounds),
  - ii) modifying the internal atmosphere, which in turn reduces respiration rate and oxidative reaction rates, as well as
  - iii) reducing or suppressing physiological disorders.
- The natural barrier that the product may have (e.g. fruits, fish), as well as the type and amount of coating, are factors that influence the extent of the modification of the product's internal atmosphere (in terms of oxygen and carbon dioxide) and the level of reduction of water loss.
- It is important to ensure that the coating has a minimal impact on the quality of the product, especially in terms of color, brightness, flavors (bitterness, acidity and sweetness), aromas and firmness.

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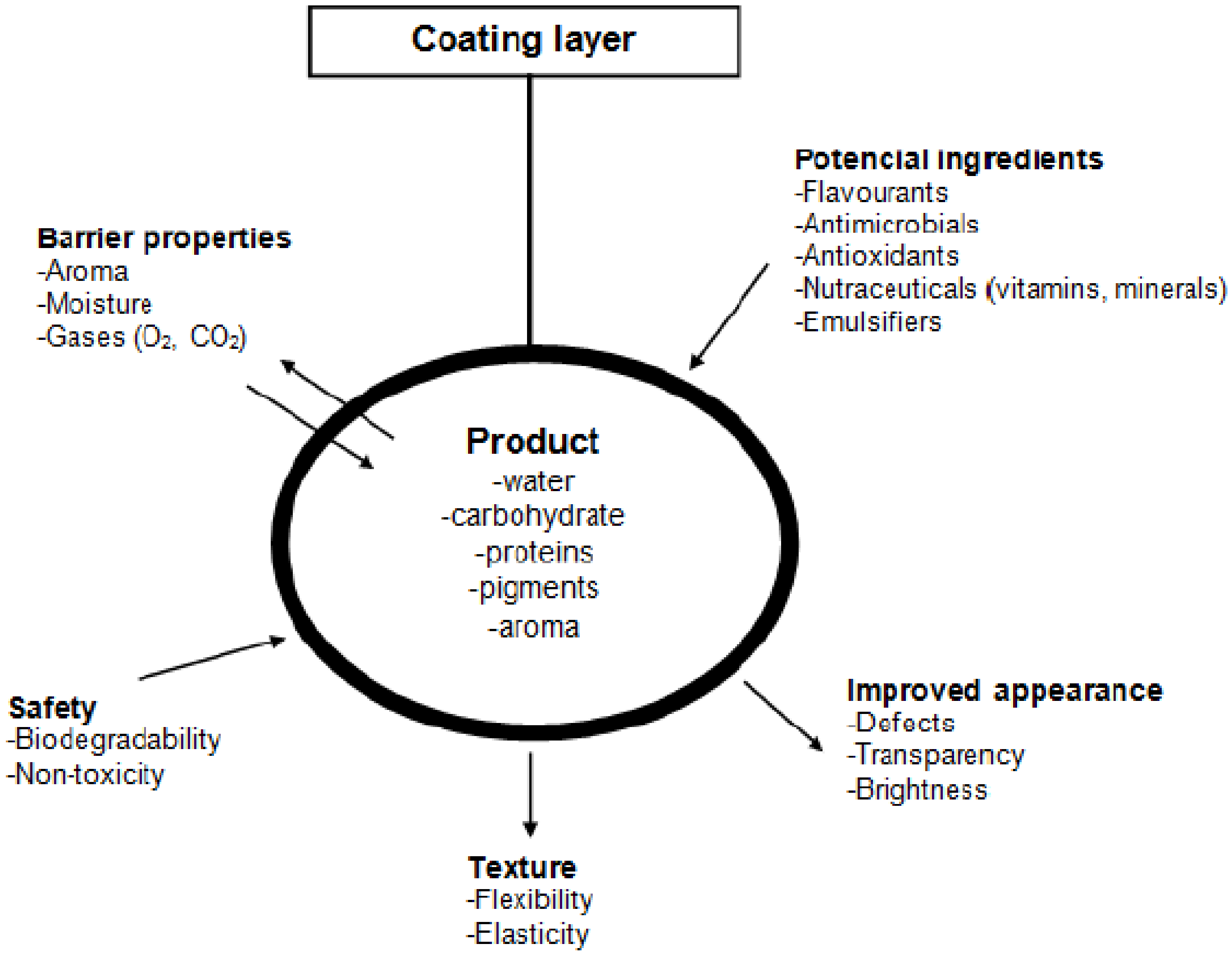
Edible coatings



Edible coatings

TECHNIQUES OF APPLICATION

- Techniques for the direct application of coatings on the surface of food:
    - immersion
    - spraying or
    - Spreading with brush

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Edible coatings

COMPOSITION OF THE COATINGS

- The materials used in the preparation of edible coatings must be generally regarded as safe (GRAS) and must comply with the legislation in force for the food product in question.

- There are a variety of compounds that can be used in edible coatings formulations, and their choice depends mainly on the application. The main components are polysaccharides, proteins, and lipids, and other minor components can be added, such as plasticizers (usually polyols, such as glycerol), surfactants, and acid/base compounds that regulate pH (such as acetic or lactic acids)

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Edible coatings

COMPOSITION OF THE COATINGS

Coatings can be divided into three categories:

- Hydrocolloids (proteins and polysaccharides), in which proteins, cellulose and derivatives are found; starches and derivatives, pectins; algae extracts (alginates, carrageenans, etc.) and chitosan;
- Lipids, in which waxes and fatty acids are found;
- Compounds, a combination of the two above, which allows a barrier to gases and water; since hydrocolloid coatings constitute an excellent barrier to gases (oxygen and carbon dioxide), but offer a weak barrier to water due to their hydrophilic nature and lipid coatings constitute an excellent barrier to water due to their hydrophobic nature.

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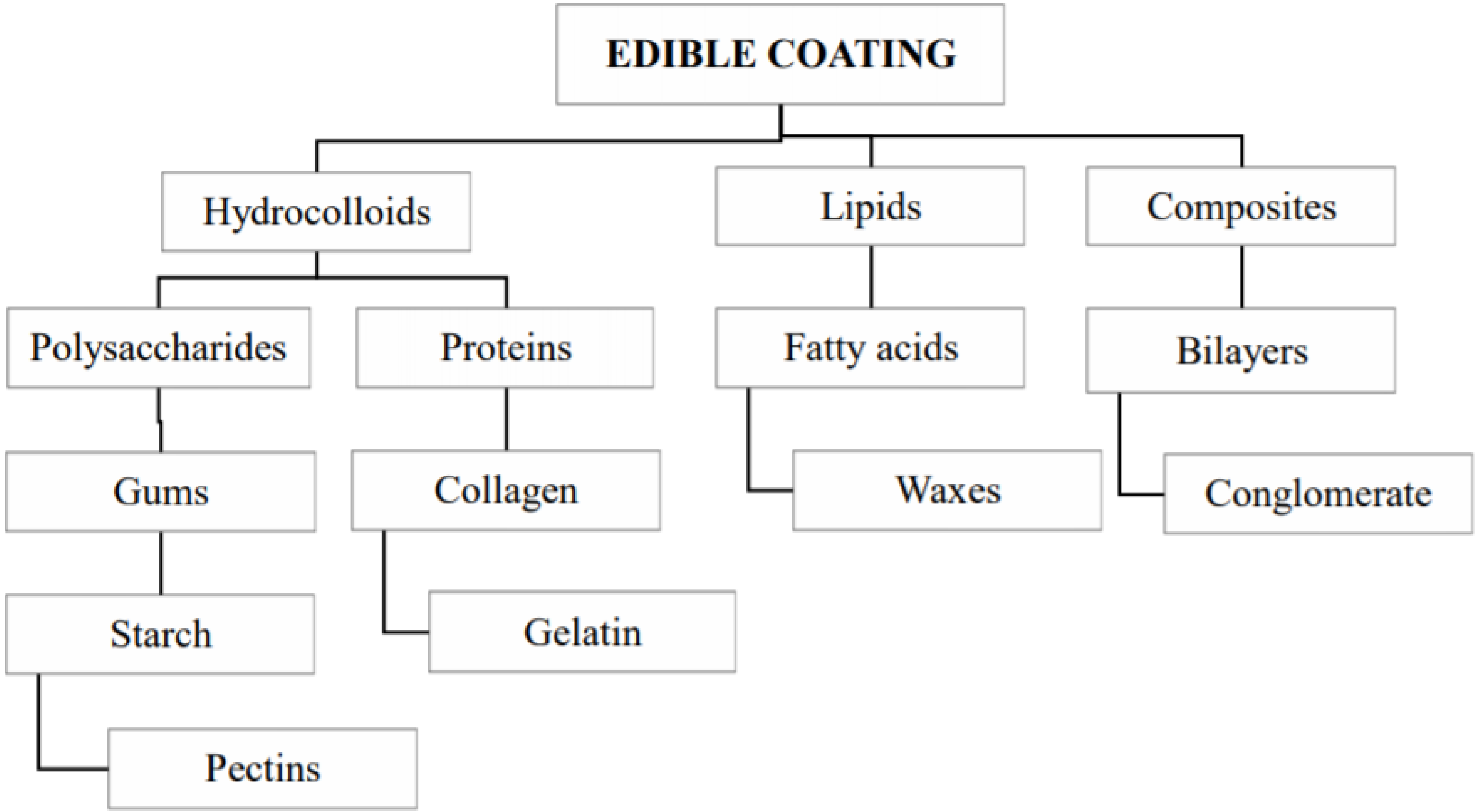
Edible coatings

COMPOSITION OF THE COATINGS



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Edible coatings

COMPOSITION OF THE COATINGS

Polysaccharides	Advantages	Disadvantages
Starch	Low cost, biodegradability and high availability	Low mechanical performance and sensitivity to moisture
Chitosan	Durability, strength and flexibility	-
Alginate	Originates strong gels or insoluble polymers	Low dimensional stability
Carrageenan	Thermosensitive	High hydrophilicity
Galactomannan	High viscosity and emulsifier	High hydrophilicity

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