Past and present trends in food packaging

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Back to the nineties

Past trends	and what happened
Active packaging	Oxygen absorbers: too expensive and complicated
Intelligent packaging	On crates & trolleys
Nanotechnology	Nano-clay is still promising rest: Science-fiction
Bio-degradable packaging	Flow-pack organic F&V

What did happen?

- Centralised pre-packing of meat, fish, cheese….
  - Rise of Modified atmosphere packaging
- Rise of the Convenience fresh food industry
  - Rise of E-MAP
- Weight reduction
- Growth of plastic packaging

Rise of MAP

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History of meat packaging in NL

- 60's
  - Supermarkets expand
  - Meat is pre-packed
    - White styrofoam tray
    - PVC stretch

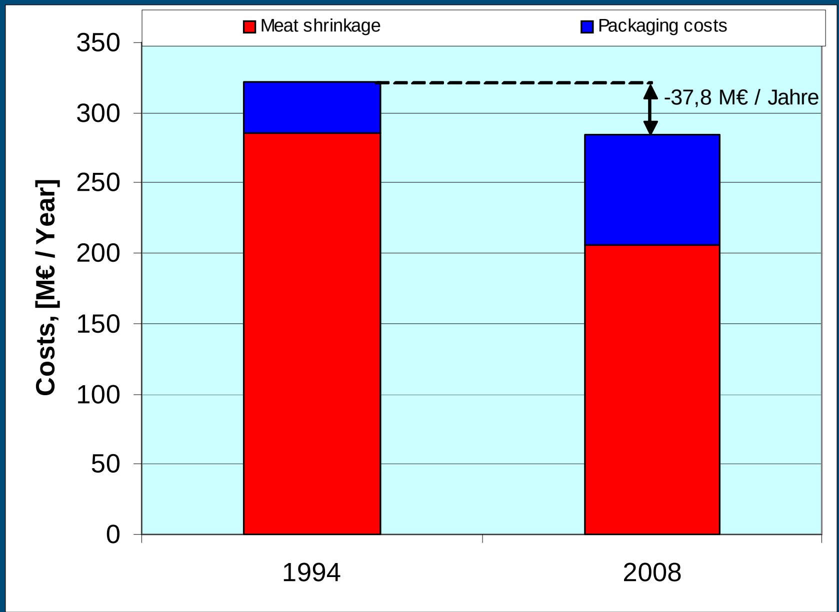
- 1964 first tests MAP
- 1975 Begin MAP
- 2000 Break through MAP
  - Large retailers start
- 2009: 60 % MAP

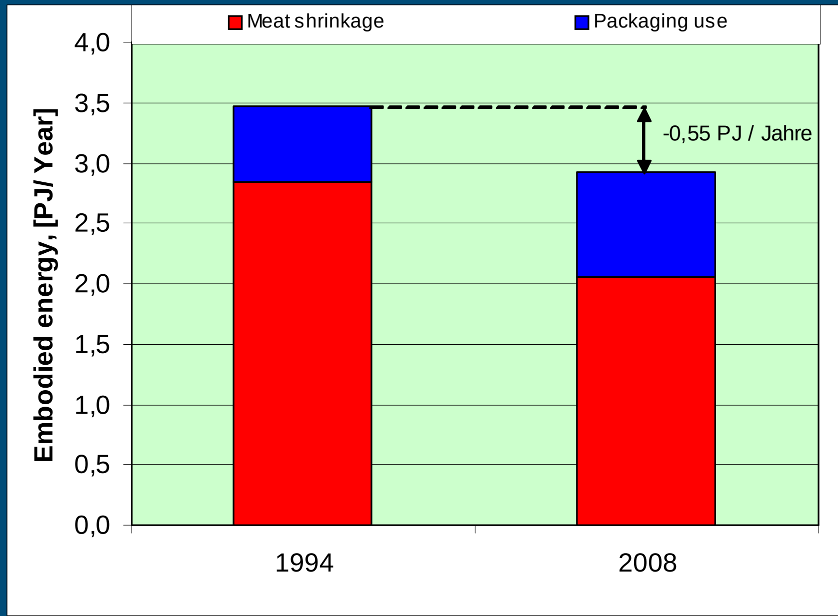
Modified atmosphere packaging for meat

- Higher direct costs +0,07 €/pack
  - Packages
  - Gasses, machines…

- Lower indirect costs <-0,10 €/pack
  - Longer shelf life
    - Less shrinkage in shops (8 - 10 -> 4 - 5%)
    - Less night shifts
    - Lower delivery frequency ….

Balances





Financial: -37.8 M€ / Year

Environment: -0.55 PJ / Year

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Rise of fresh cut Industry (E-MAP)

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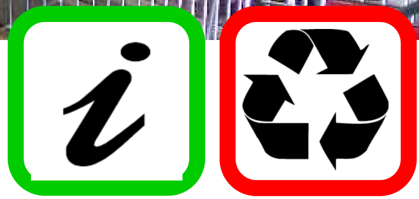
Fresh cut food products – *Dutch perspective*

- Important
  - Largest source of income for Dutch retail
    - Fresh turnover 10 B€
    - Fresh cut greens turnover > 750 M€ in 2005, +14% /yr
  - Traffic generator
  - Trends:
    - Fresh = healthy, tasty, convenient
- Complex
  - Fresh produce lives
  - Quality varies > 100%
  - Sourcing issues
  - Large portfolios
    - 100-250 fresh cut fruit and vegetable products / shop

Pre-packed fresh cut products



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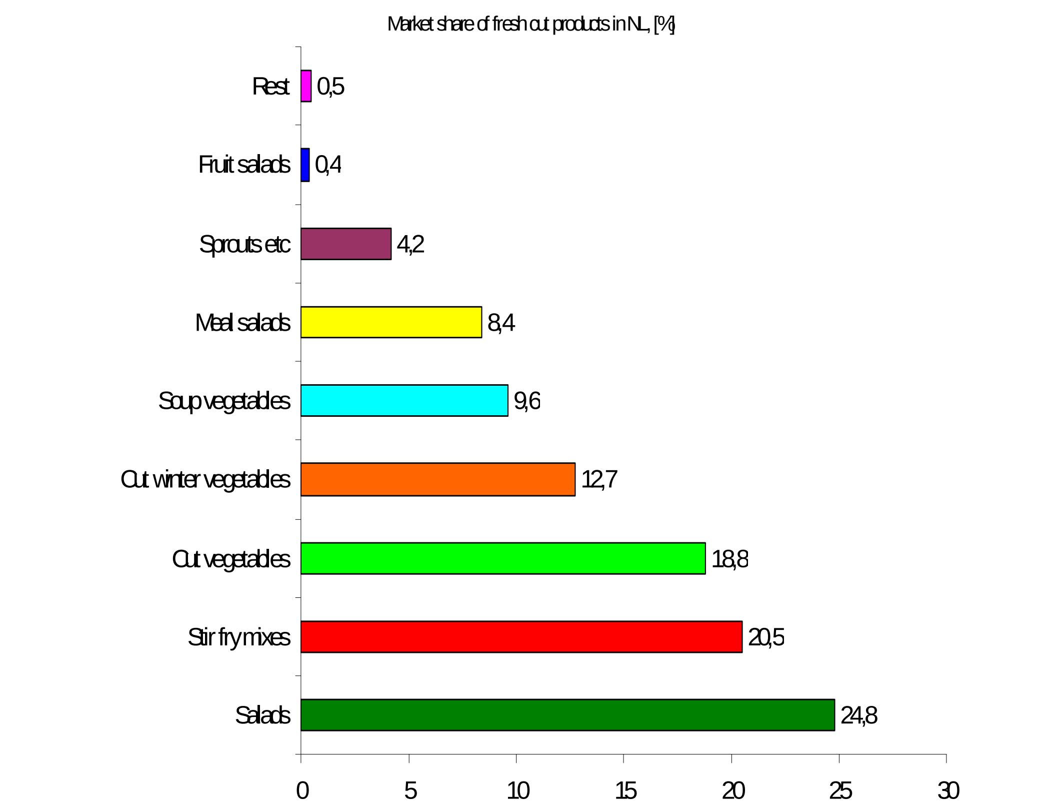
Development fresh cut industry

- 70’s: few offerings
- 1985 Iceberg lettuce
- 90’s: enormous growth
- Largest change in retail



Supply chain organisation

Retail ← Fresh cut industry ← Produce trade

Fresh cut industry ← Film suppliers

Fresh cut industry ← Machine builders

- Target = Profit for retail
  - 100% private label with contract suppliers
  - Free trade, no contract farming
  - Very competitive field for suppliers

- Packaging technology made it possible!
  - Every fresh cut producer via *trail-and-error*

Respiration

- Complex
- From 1 to 300 ml O_2/kg.hour

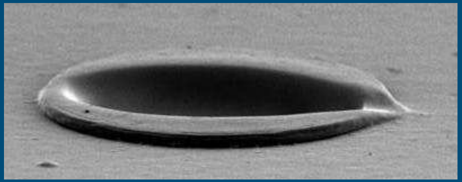
$$R_C = K_1 \cdot \exp\left(\frac{-E_a}{R \cdot T}\right)\{1 + K_2 \cdot \exp(-k_d \cdot t)\}$$

$$vO_2 = v\max O_2 \times \left[\frac{O_2}{(KmO_2 + O_2) \times (1 + \frac{CO_2}{KmnCO_2})}\right]^x$$

$$V_{CO2} = RQ_{ox} \cdot V_{O_2} + \frac{Vm_{CO_2(f)}}{1 + \left(\frac{O_2}{Kmn_{O_2(f)}}\right)}$$

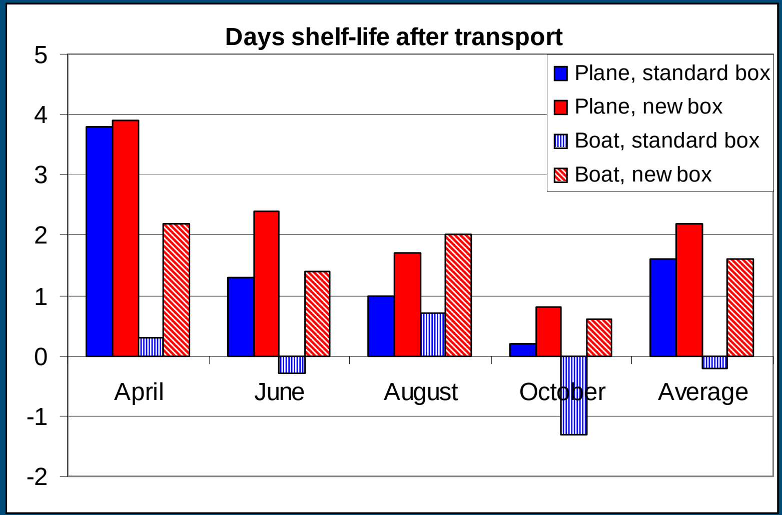
- Flow-packs (20 x 30 cm):
- -> 300 – 100.000 ml O_2/m^2.bar.day
- -> 500 – 300.000 ml CO_2/m^2.bar.day

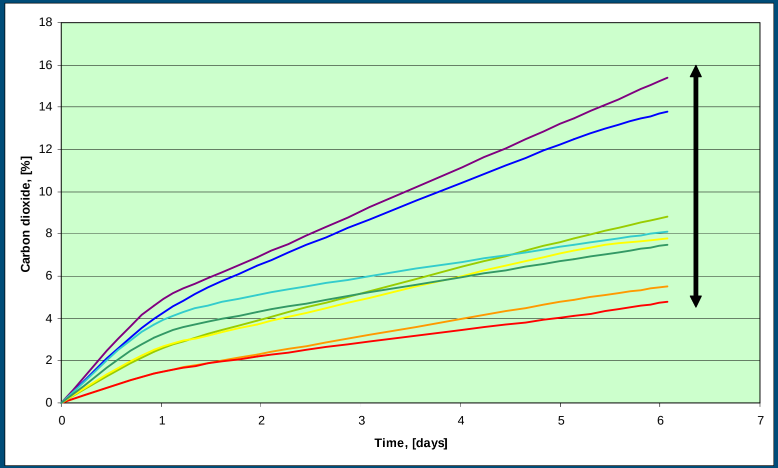
- Mostly used solutions
  - BOPP/CPP/AF + micro-perforations



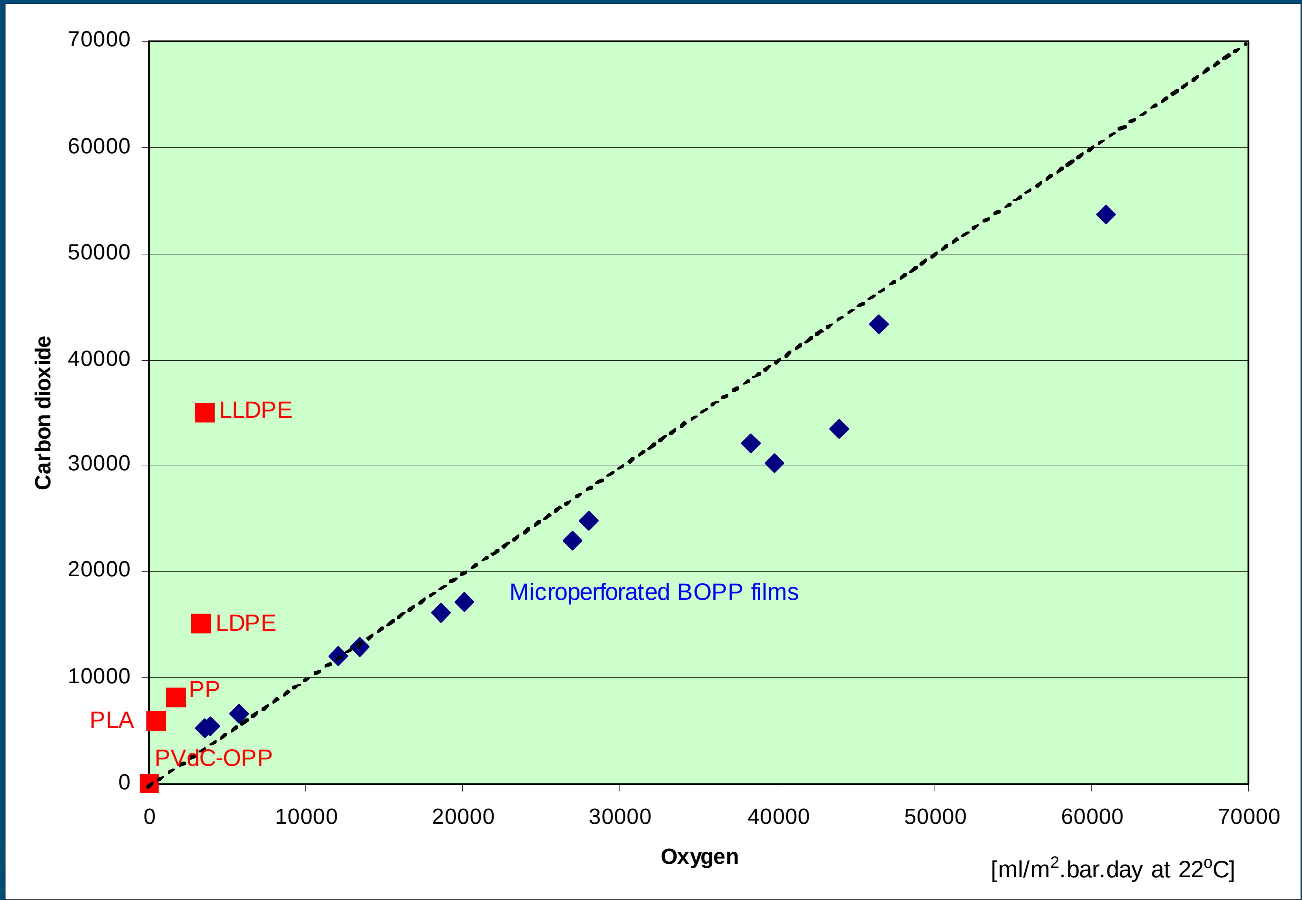
Variation in quality

- Large difference between reality and theory (Literature)
- Variations of >100% in:
  - Microbiological load
  - Respiration activity
- Origin, harvest method, growing conditions, seed type….
- Simultaneously:
  - Control the initial quality and
  - Optimise packaging





Commercially applied flow-pack films



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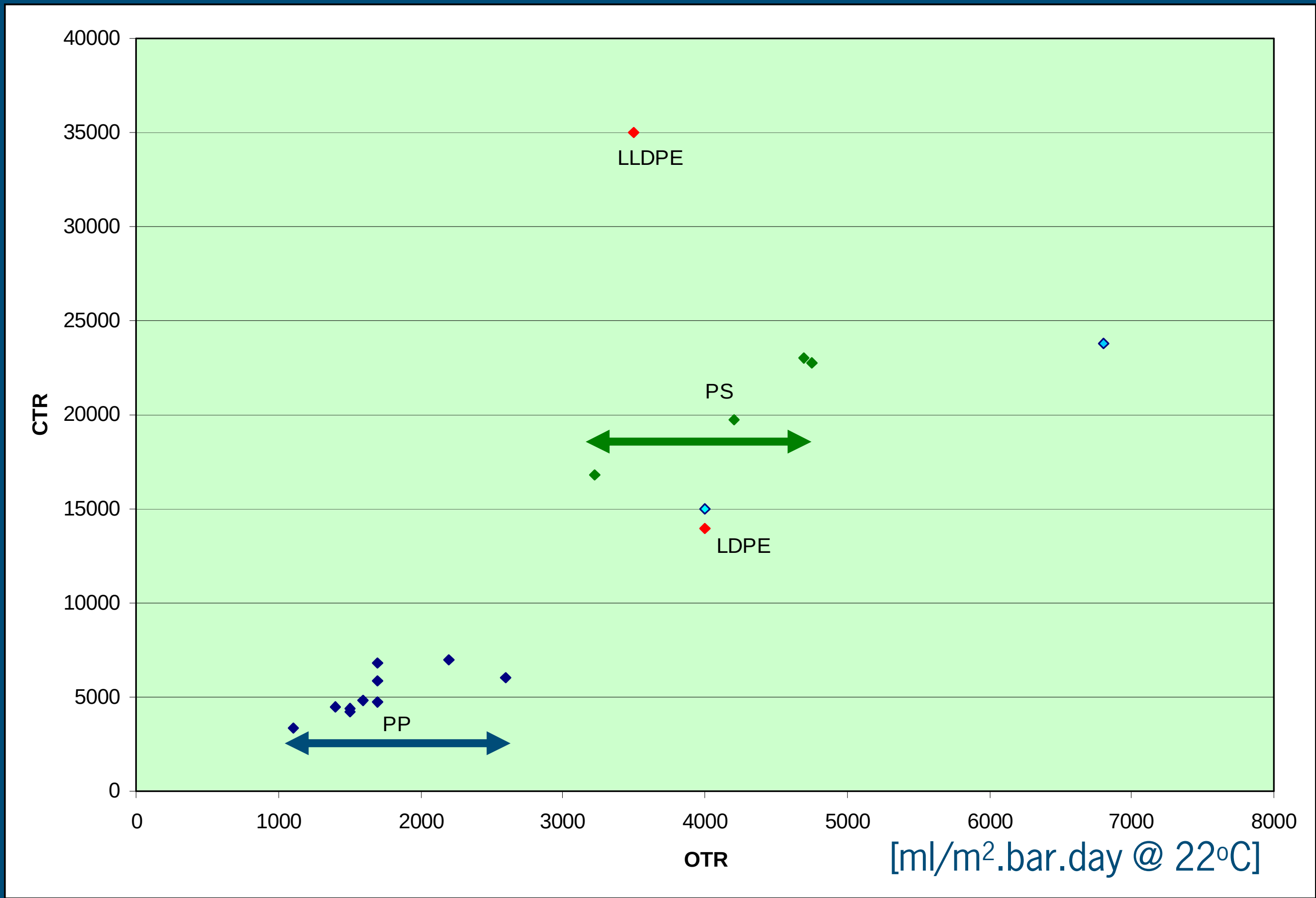
Closer view


40000
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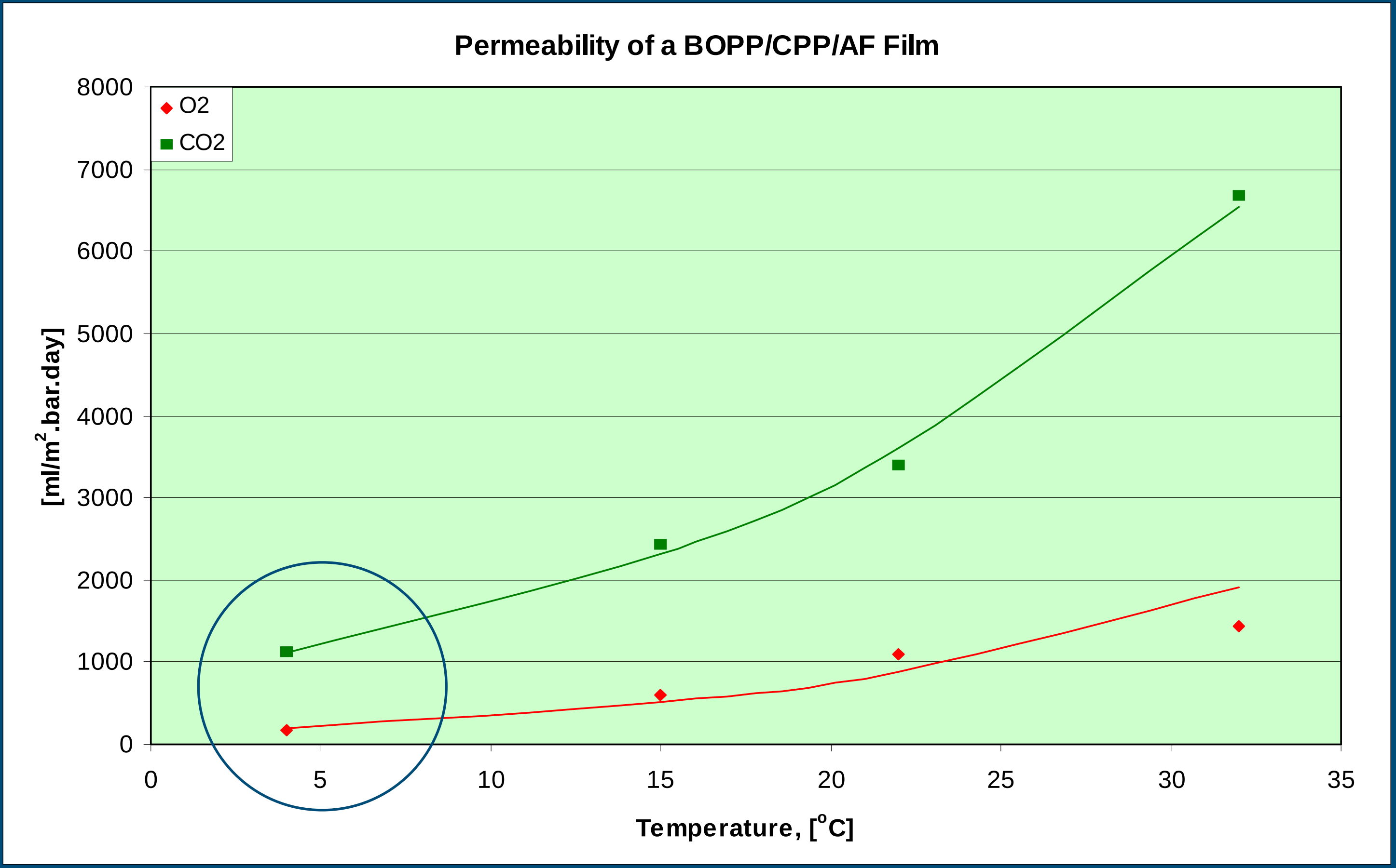
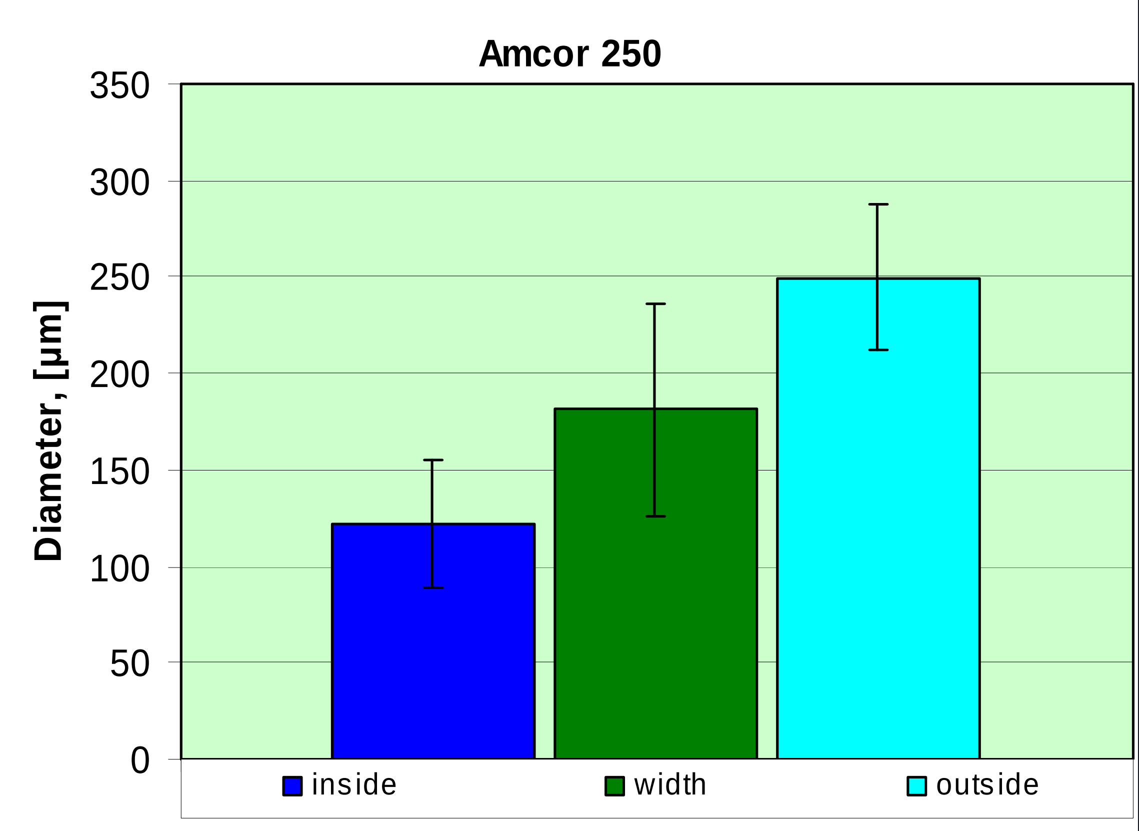
5000
6000
7000
8000
OTR
[ml/m2.bar.day @ 22oC]

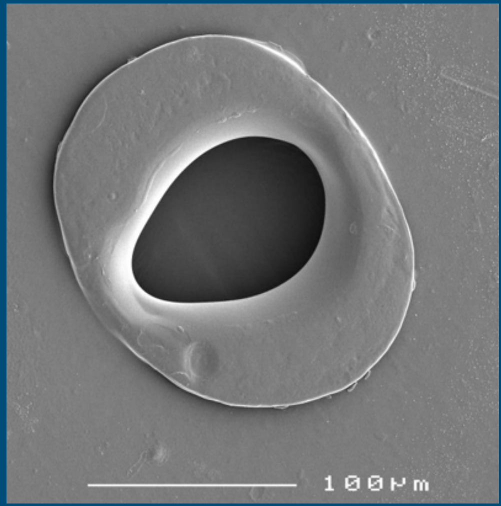
Temperature dependance

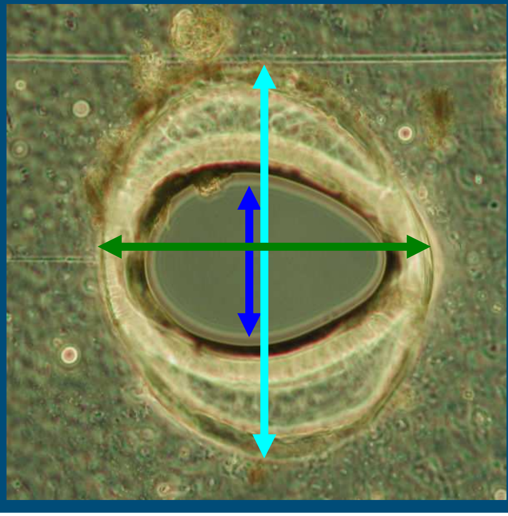


OTR, CTR and WVTR need to be specified at 7°C and 80-100%RH

Laser perforated films







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Successful E-MAP applications

- Strawberries – soft fruit
- Broccoli
- Chicory
- Stir fry mixes
- Soup vegetables
- ....

Strawberries in MAP

Shelf life

18^oC 5 -> 7 days

12^oC 6 -> 8 days

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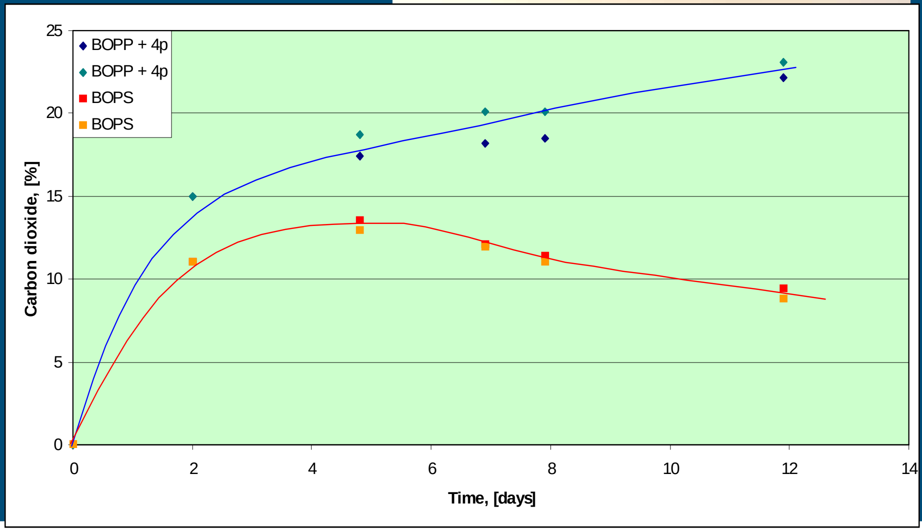
MULTIVAC
BETTER PACKAGING

Stir fry mixes

- 5-10 Products in mix
- Optimal pre-treatments
  - Decontamination whole products
  - Cutting method
  - Washing method
  - Edible coatings (Ca^{2+}, vitamin C)

- Flow-packs with 2-6 Micro-perf.
  - Compromise atmosphere
  - 5-7 days of shelf life



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Anaerobic E-MAP

- Method to avoid discolorations / enzymatic browning

- Control the influx of O_2
  - Not too much → Discoloration
  - Not too little → Fermentation
- Control the outflux of CO_2
  - Avoid suffocation in high CO_2 atmospheres
  - Raise α (CO_2/O_2)

E-MAP for double fresh meals

- Steam and cook meals
  - 2005: 5-7 days SL -> 20% shrinkage -> 5 €/meal

- Solution
  - Optimally fresh vegetables
    - Quality focussed purchase
    - Pre-treatments
    - Decontamination
  - Optimal E-MAP for freshly cut vegetables
  - Protective marinade for meat / fish component
- SL of 9-12 days feasible

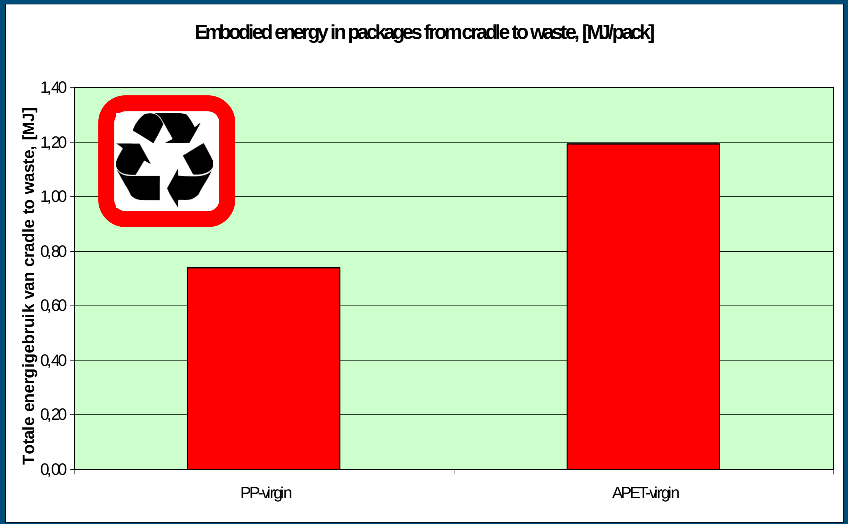
3 Steps towards a high quality fresh cut product

- 1 Temperature ↓
- 2 Control initial product quality
  - Quality oriented purchase policy
  - Decontaminate
- 3 Optimising packages

- Best Process
- Best Products
- Best Package

Top-seals for luxury salads

- Marketing
  - PET & Alu. > cla.-PP, PS > PP
- Product quality:
  - PS > PP > PET & Alu
- Costs
  - PET vs PP: Δ€ =+0,04 €/tray
- Environmental impact
  - PET vs PP: ΔEI = +0,45 MJ/tray



Rise of the fresh cut industry in NL

	1985	2005
Turnover, [M€]	<1	750
Profit, [M€]	<1	>300
Packaging use, [ton]	~0	+1700 BOPP film +500 PET trays

Weight reduction and the growth of plastic packaging

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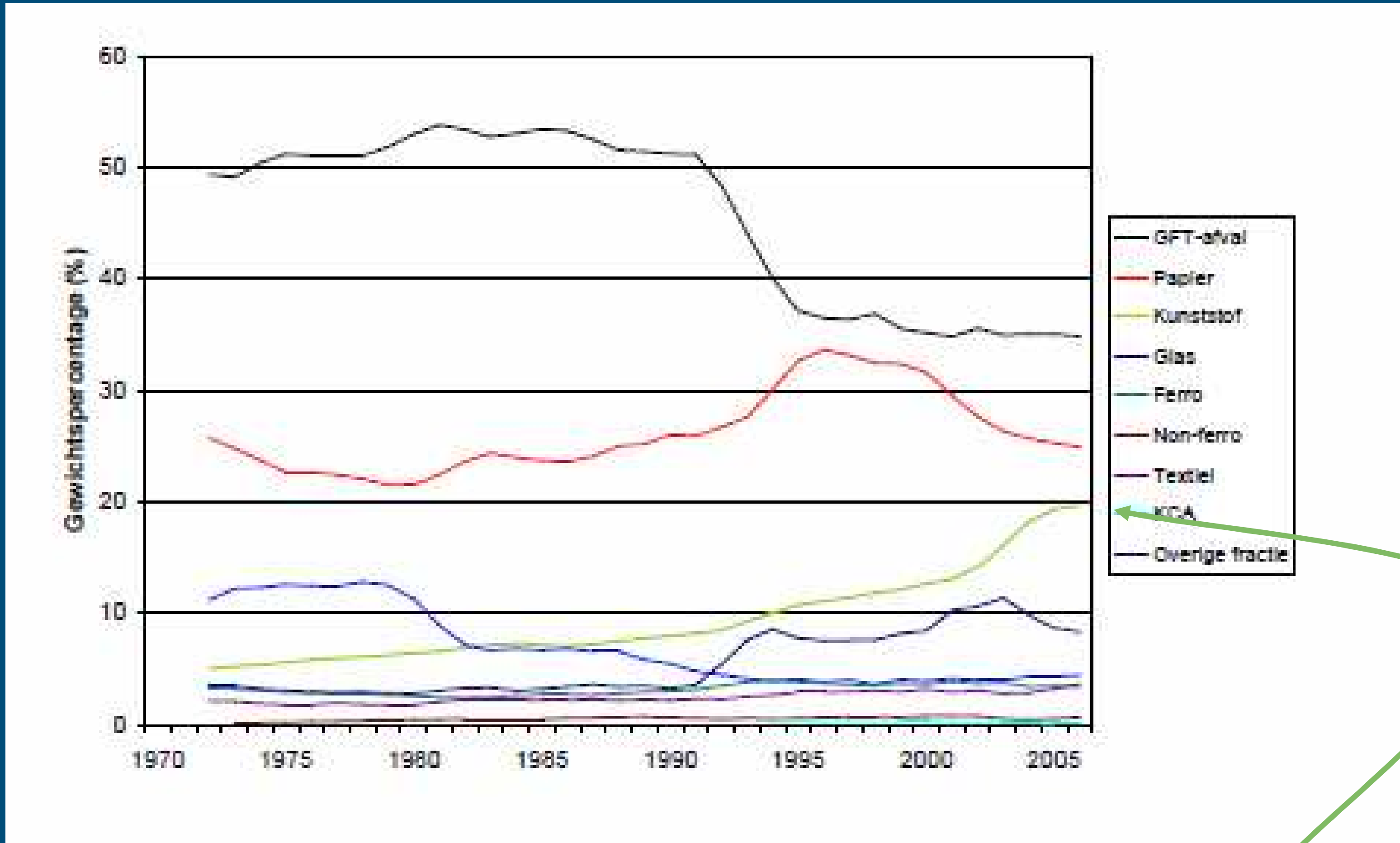
Growth of plastic in Dutch MSW



Plastics packaging in MSW ~ 630 kton / year

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Weight reductions

- From cans + glass jars to laminated board
- Thinner PET bottles…

- From thicker laminated films to thinner metallised / coated films

- GUA: plastic packaging most eco-efficient

Past trends in retrospect

Active packaging

- Oxygen scavengers work great with:
  - Nuts, coffee, tea, cured meat, beer
  - Post-pasteurised meals….
- Not applied
  - Costs > +0,01 € / pack
  - Production logistics
  - Difficult to integrate
  - Limited capacity of integrated absorbers
- No quality benefits confirmed under real-life test conditions for:
  - Controlled release systems
  - Ethylene scrubbers
  - CO_2 release systems
  - ….

Controlled release ?

- Anti-oxidants, Anti-microbial agents, enzym inhibitors…

- Anti-microbial agents most widely studied
  - Only benzoic acid / sorbic acid are double allowed
  - Ag^+/zeolites does not work
  - Essential oils work best as part of a marinade
  - Musterd oil & cheese -> strong off taste in first weeks
  - Chitosan film -> production, sealing issues and costs

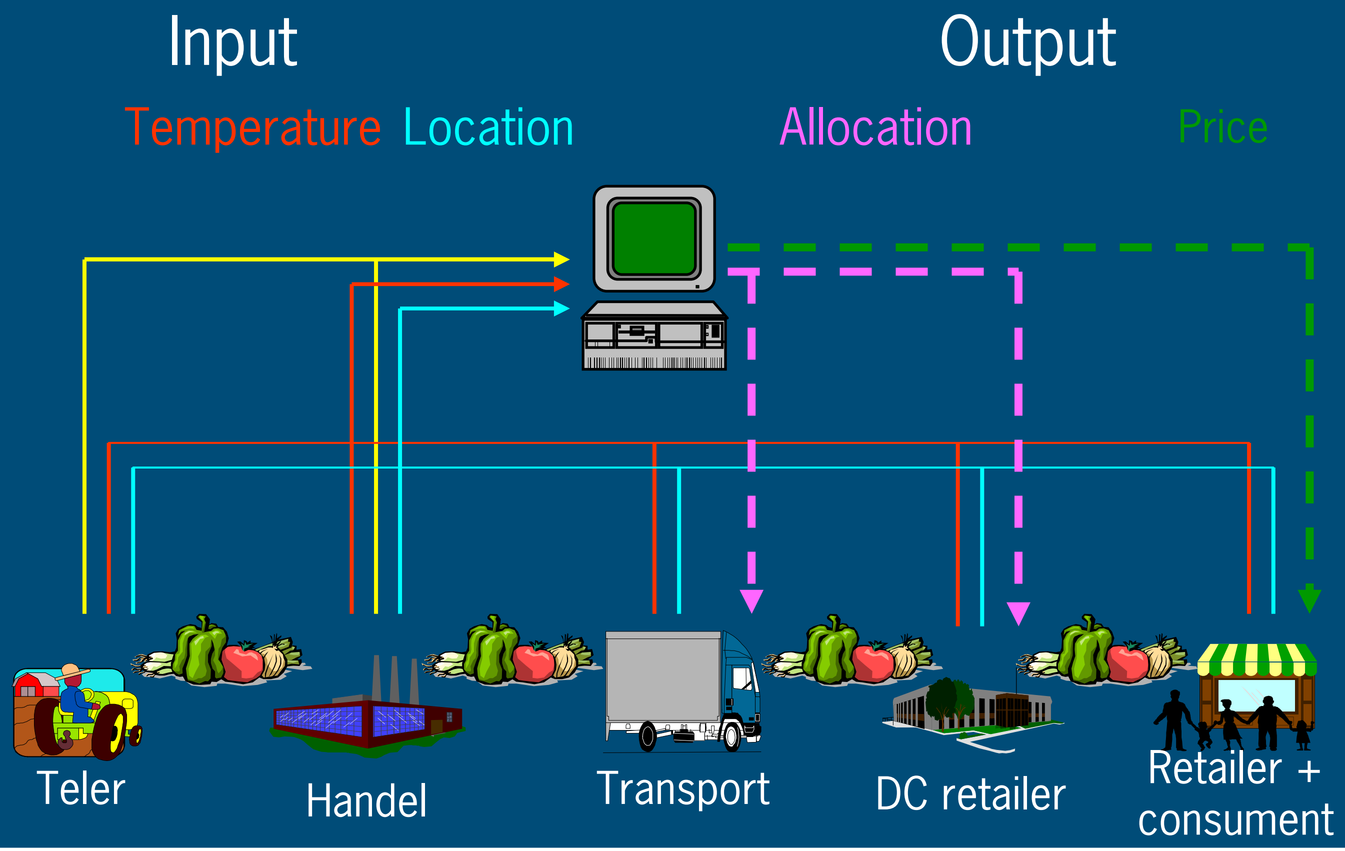
Intelligent packaging?

- Packaging that reports information on the quality of the packed goods to outside world
  - Quality sensors, pH sensors
  - Time-Temperature-Integrators
  - RFID+temperature/RH sensor

- Forms
  - Most simple: label that discolours at a threshold temperature
  - Most elaborate: RFID+

Advanced stock management systems

- Product shrinkage NL: 1 billion € / jaar



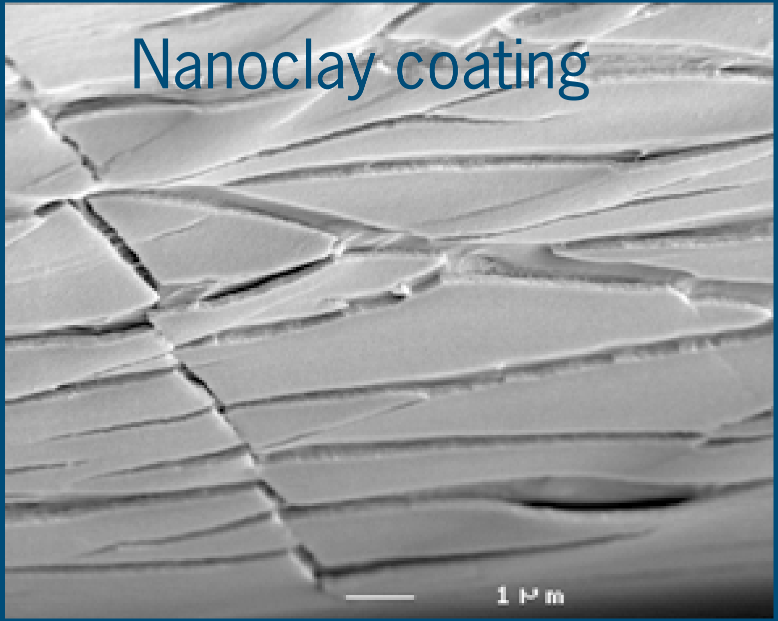
Intelligent packaging

- Often used:
  - temporarily to optimise food chains and find and solve bottle-necks
  - on crates/ trolleys to reduce lost cargo in supply chains
- No systematic use in supply chains on consumer packaging level
  - Investment costs in equipment and business culture change are too large
  - Retailers do not want to infringe their fresh image

Nanotechnology

- Nanoclay barriers
  - In development and difficult
    - Exfoliation in polymers
    - Colour
    - Temperature sensitivity
  - Large potential for material reduction
  - Migration test procedures for approval still unclear
    - Although there is no prove for real danger

- ~~Sensor & actuator technology in packages~~
  - ~~Science fiction~~



Bio-degradable and renewable packages

- Current applications
  - Beer cups
    - PLA does not splinter
  - Organic fresh produce
    - Avoid upsetting the heavy users of organic food
    - Cheapest campaign to promote a sustainable image
- Other applications: difficult to get equal performance
- Generate free publicity

Environmental impact of packages

- Energy balance → CO_2 formation → GWP
- Formation of final waste
- Depletion of non-renewable raw materials
- Additives
  - Not dangerous for the human, but for the planet?
  - „molecule of the month‘

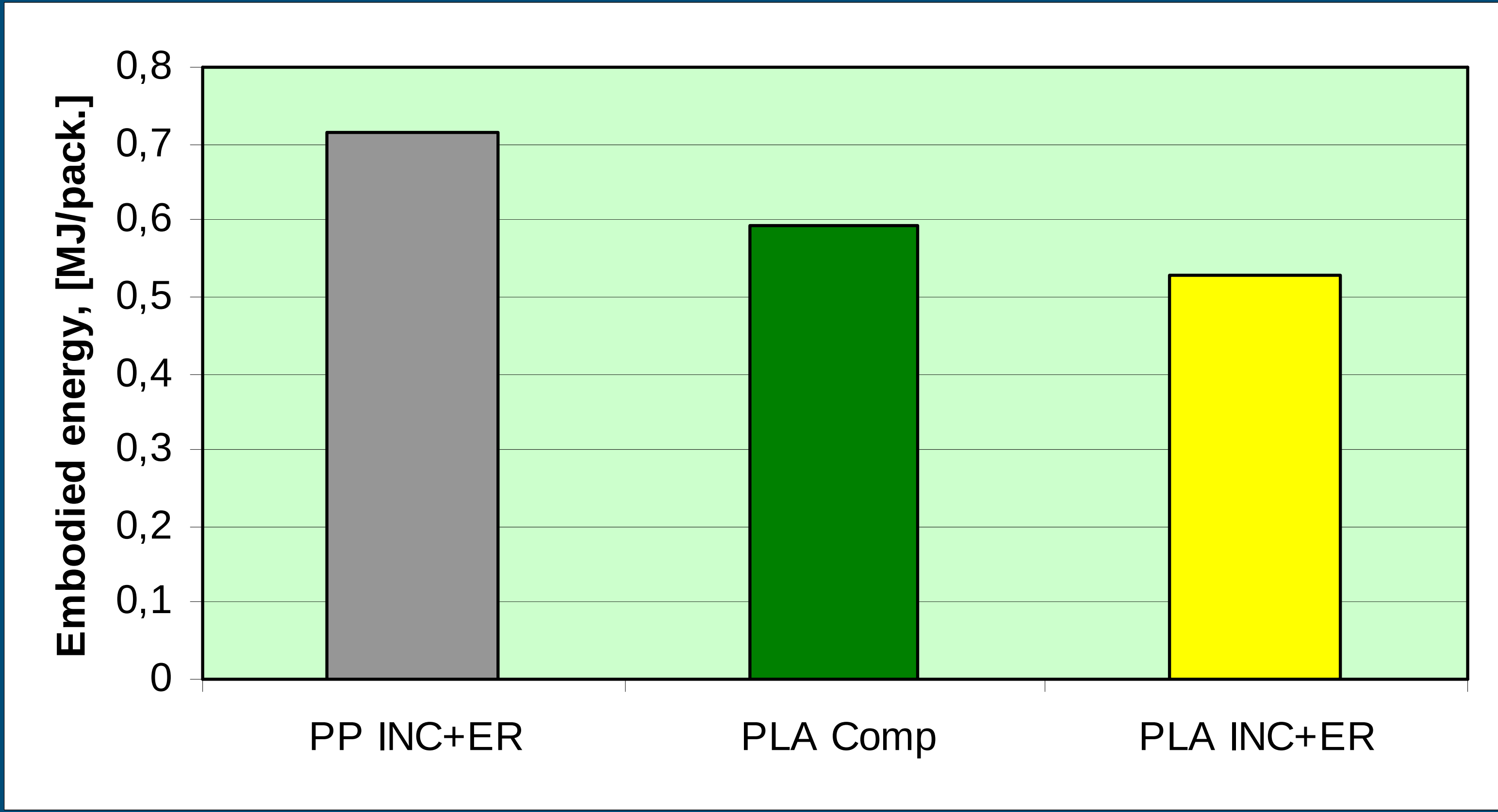
Environmental impact of packages

Production → Use → Disposal

- **Production**: Often less embodied energy in bioplastics
- **Use**: Often need more bioplastics for equal performance
- **Disposal**: Incineration with energy recovery is better than composting

- Bioplastics can be better, especially when there are few technical (permeability) constraints and the household waste is incinerated with energy recovery

Energy balance for yoghurt cups



Take care: different for every application, do not generalise!

Bio-barriers

- Various bio-barriers in development
  - PLA-SiOx-PLA
  - PLA-PVOH+nanoclay
  - Starch laminates
- Problems with
  - Machinability
  - Permeability

- Applications of fresh foods with medium shelf life (4-6 wks) in barrier packages not successful yet

Bio-degradable packages

- Price: always (a bit) more expensive
- Performance: equal or less
- Environment: sometimes better, sometimes not



Present trends - 2020

- Lighter & thinner packaging
- Fresher products:
  - Best product + best proces + best package (E-MAP)
- Renewable packaging
- Recyclable packaging

Packaging recycling: what should happen

Growth of plastic packaging -> recycling

- Plastic packaging is a integral part of an efficient modern society
  - GUA: without, CO_2-emissions would be much larger
- But the relative growth of plastic packaging is non-sustainable
  - Political need for efficient recycling programs
  - Without a clear business need to do so

Political motivation for recycling

- Plastic packages contain energy
  - NL > 60 PJ (2% national energy use)

- Crude oil will become expensive in 10-50 years

- Long term strategy:
  - Recycled plastics for the most demanding applications
  - Biobased plastics for less demanding applications

The ideal situation

- Efficient recycling system
  - Low costs and high yields
  - Recycling system costs < costs for virgin polymers
  - Impurities should be dealt with
- Sorting and reprocessing should be done within Europe
- Process should yield regranulate that ultimately can be used in the packaging industry
  - Is partially possible, but not implemented yet

Recycling: not a cycle but linked chains

Deposit refund

- Citizens
- Retailer
- DC
- Counting centers
- Reprocessing

Products

- HQ PET regranulate
- MQ PET regranulate
- PO scrap etc.

Source separation

- Citizens
- Separate collection
- Sorting centres
- 6 reprocessors

Main products

- PO mix regranulate
- LQ PET regranulate
- PS regranulate
- …

Commingled collection

- Citizens
- MSW collection
- Plastic recovery
- Sorting centres
- Reprocessors

Main products

- PO mix regranulate
- LQ PET regranulate
- PS regranulate
- ….

Deposit refund systems

- Suitable for few types of packaging: 4-5%
  - Large PET soda bottles
  - Large HDPE washing liquid bottles

- High (hidden) costs
  - Labor, floor space, RVM's
  - Costs are 2500-3000 €/ton

- But for 17% B2B recycling!

Source separation of plastic packaging

- Mostly used system in EU
  - High response rates are claimed, but:
    - 5-30% is impurity
    - 10-30% overall material reuse
    - Rest for energy recovery
  - Substantial costs are made for collection, sorting and reprocessing
  - Materiel reuse at best: non food packaging, no recycling
- Need for more efficiency
  - New process technologies
  - Simplified business chains
  - Cost reduction

Commingled collection and centralised recovery

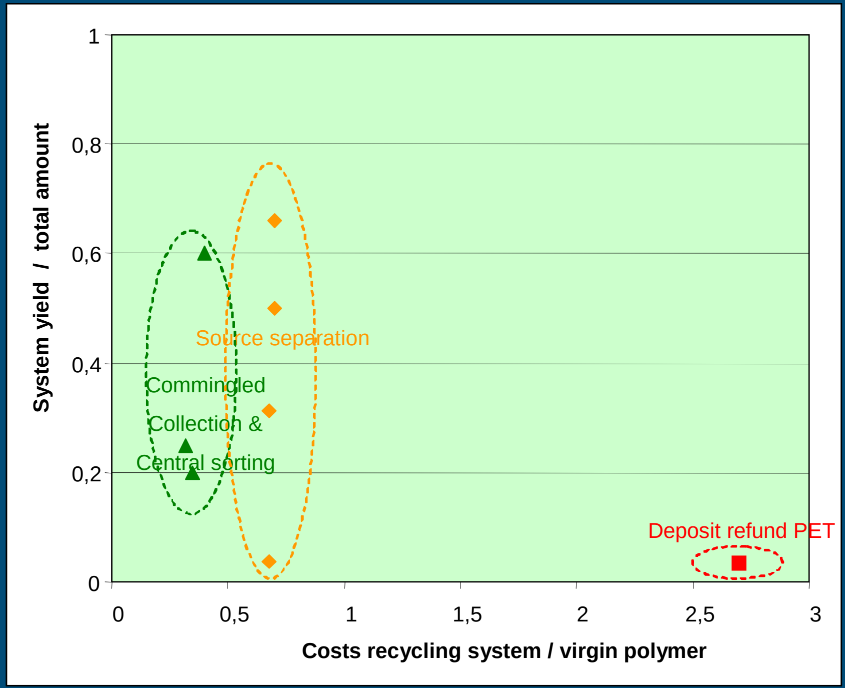
- Plastics can also be automatically be separated from MSW with MRF
  - Lower qualities
  - High recovery rates possible
  - Rigid and Flexible packaging recovered
- But:
  - Few existing waste companies can add a MRF
  - New recycling processes needed to deal with this new quality





System performance

- Too early for a full evaluation
  - Process chains are not completely formed, yet
- Major uncertainty:
  - Possible higher processing costs for plastics recovered from MSW
  - More overlap expected



Future outlook

- Long term strategy:
  - Recycled plastics for the most demanding applications
  - Bio-based plastics for less demanding applications
- Plastic recycling needs to mature fast
  - Collection cost reductions (politics)
  - New processing technologies (innovation)
  - High level applications: packaging (re**CYCL**ing)

Thank you!

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