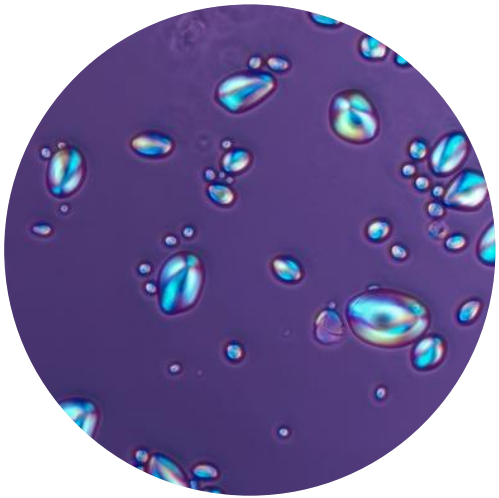
Latest developments on starch-based plastics

Fresia Alvarado Chacón

Circular Biobased Products Symposium

June 22nd 2023



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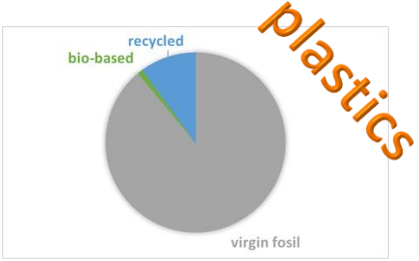
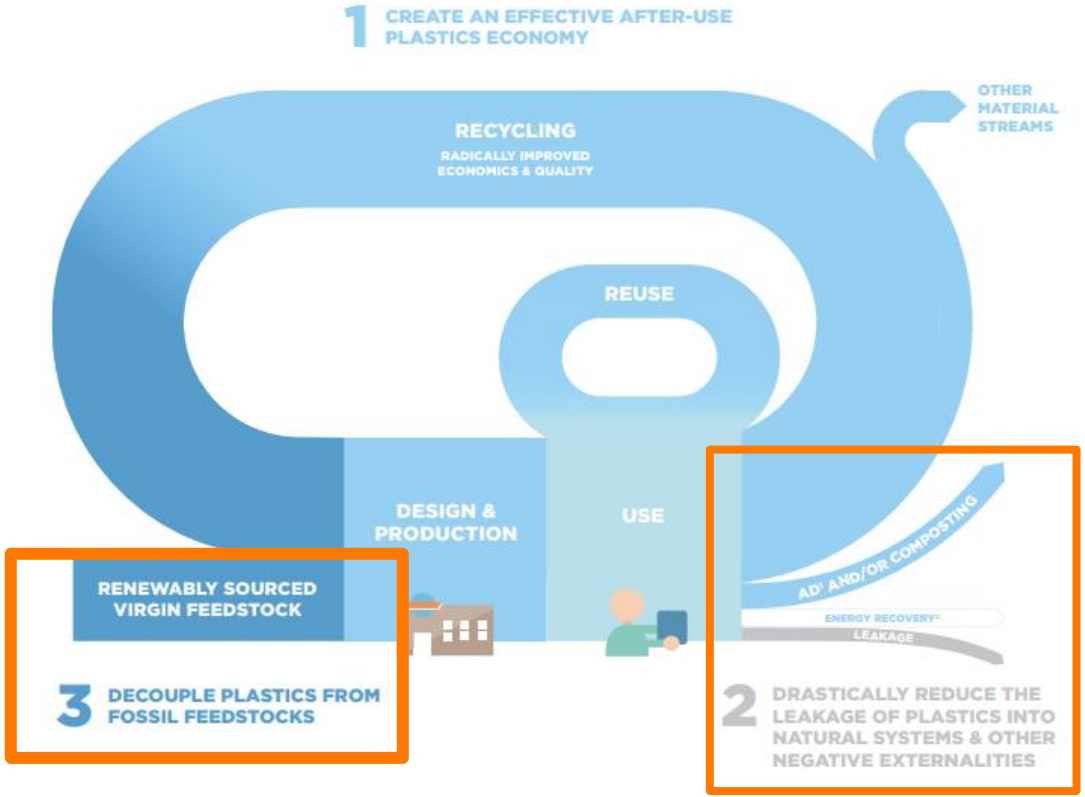
Actual problems

- CO_2 emissions
  - Climate change
  - Floods
- Dependence on oil
  - Depletion issues
  - Polluting methods to access it
  - Price
- Insufficient waste management systems



Renewable plastics research at WFBR

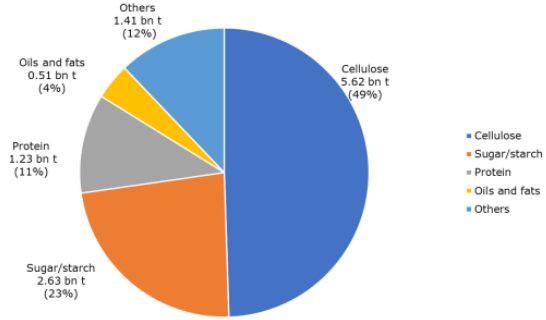
Towards a circular plastics economy



Source: https://www.ellenmacarthurfoundation.org/

Why starch?

- Highly abundant renewable resource
  - Second most abundant polysaccharide
- Perfect fit for different end-of-life options

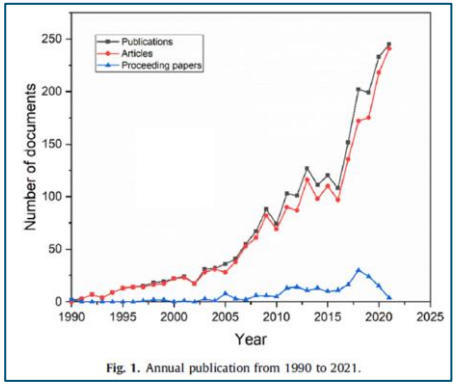


Source: Piotrowski, et al, 2015, Nova Institute.

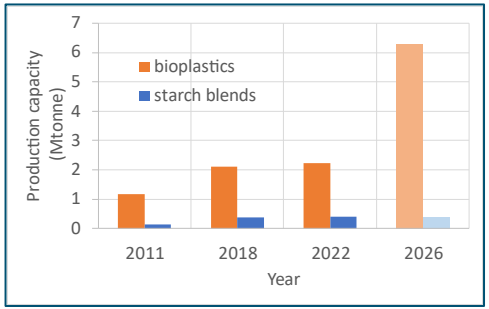
Source: www.renewable-carbon.eu/graphics

Starch in the literature and in the plastic market

- Bioplastics market expected to increase
- Renewed interest in starch-based plastics



Source: Nordin et al. Starch based plastics: A bibliometric analysis. Materials Today, 2023.

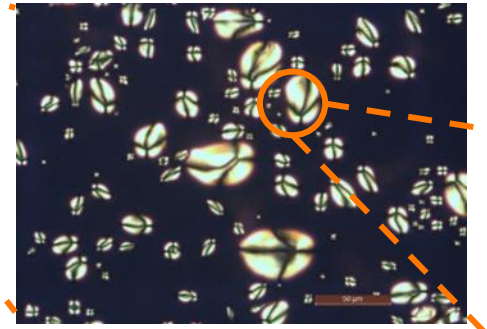


Source: data from European Bioplastics and nova institute

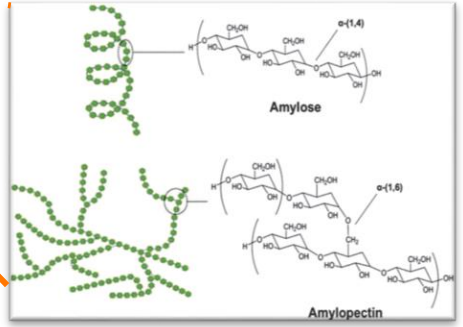
Traditional sources of starch

Different sources in nature:
Potato, corn, tapioca, etc
10-20% water content

5-100 µm



- Native is granular
- Different shapes and diameters
- Gelatinization vs melting



Amylose and Amylopectin
High molar mass
Semi crystalline

Alternative starch sources

Side streams – rejected bananas
15-20% of total production!!
At least 315 kton/year

Alternative crops – sago palm
Grows naturally in peatland

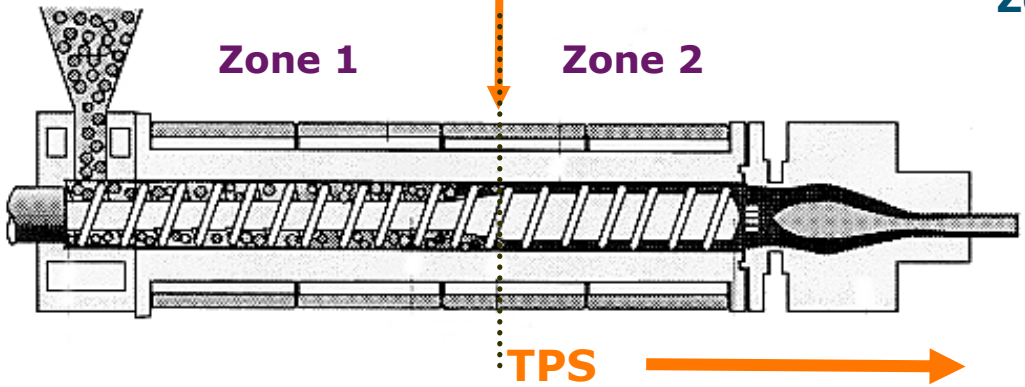
Side streams – starch from oil palm trunks

From starch to thermoplastic starch (TPS)

Starch in powder form

Starch, Plasticizers,
Additives, Water

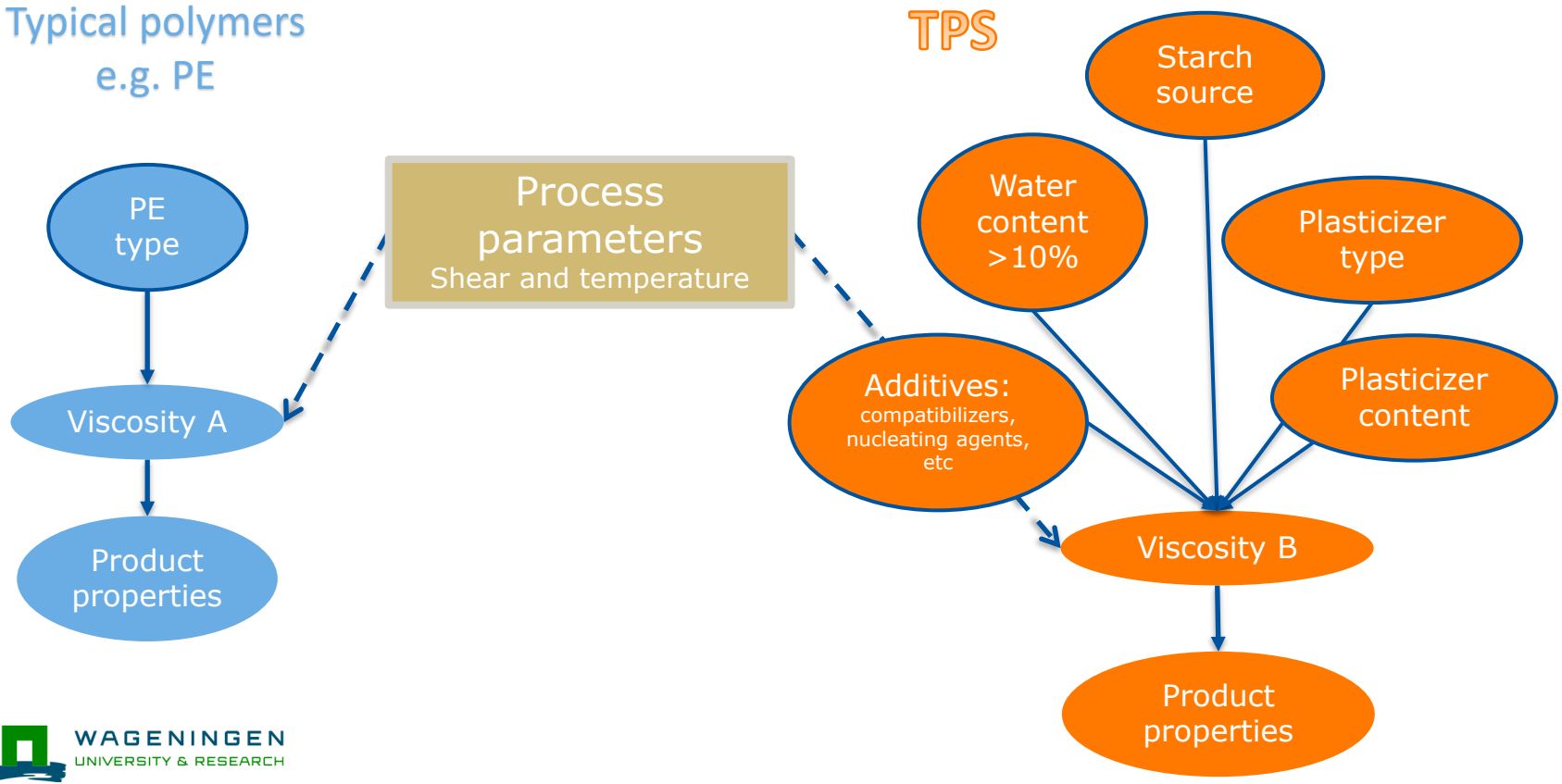
Gas
Additives
Compatibilizer
Second biopolymer



Zone 1) Melting or gelatinisation
Zone 2) Blending/transport

Granulate (or foam)

Typical polymers vs TPS



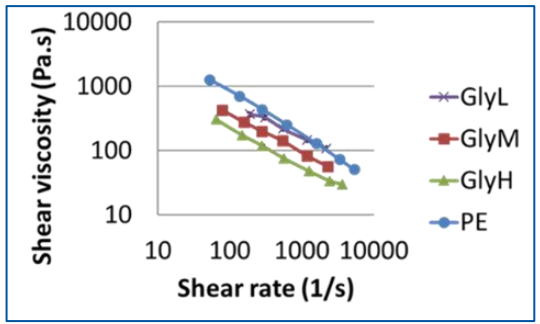
TPS characterization technologies

Typical polymers

Offline Capillary Rheometer

+ Shear rates comparable to extrusion

- Till now not possible to measure high water content (>8%)!

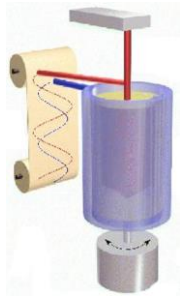


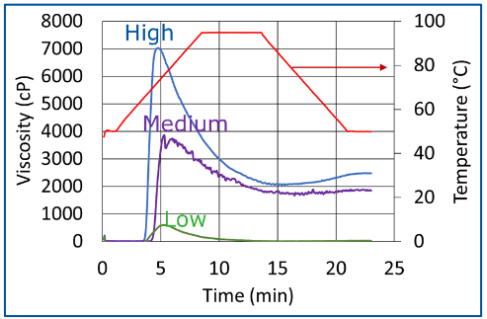
Typical starch

Rapid Visco Analyser (RVA)

+ Information on gelatinisation peak, end viscosity at high water contents

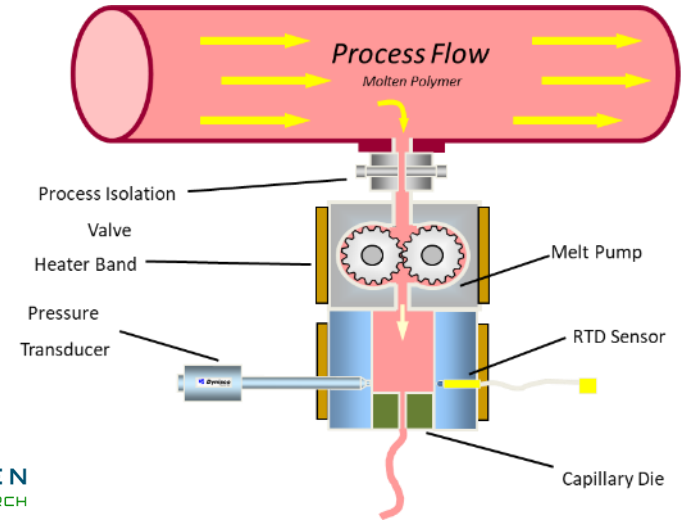
- Relatively low temperatures and shear





Compounds: In-line Capillary Rheometer

- Directly connected to extruder
- Possible to measure mixture at high water contents!



Dynisco

Project: Carbohydrate-based foam as sustainable thick packaging material

Project goal

Development of (a new technology for the production of) thick-walled starch based packaging materials suitable for packaging heavy products

Project period: 01/2018 – 12/2021

Topsector Agri&Food

TKI Agri&Food
Postbus 557
6700 AN Wageningen
www.tki-agrifood.nl

Project partners

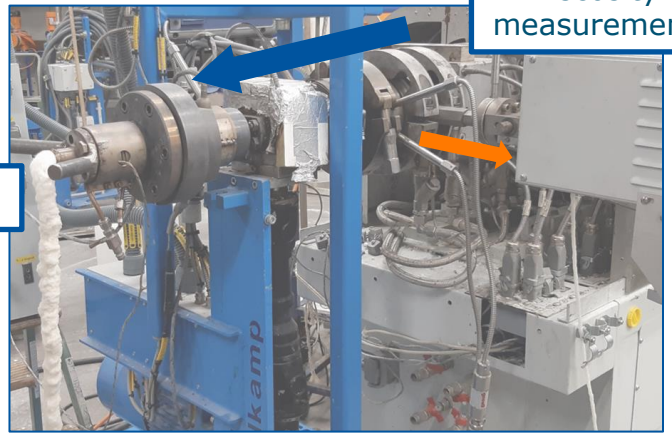
BEWI

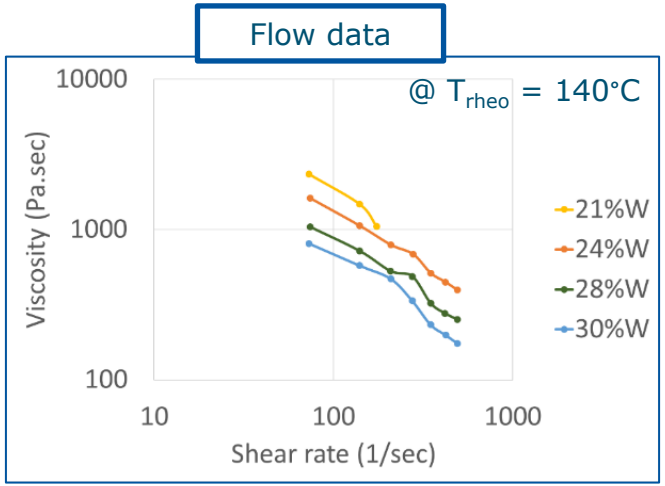
paxpring

PaperFoam®

Packaging towards a sustainable future

Characterization of starch formulations

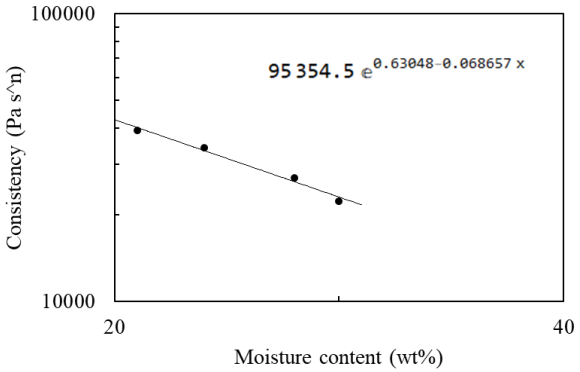


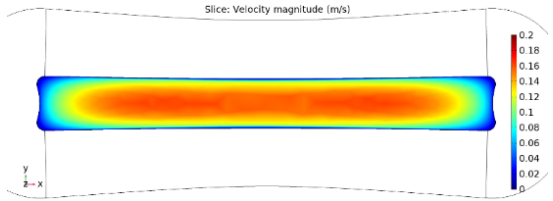


- Complete formulations are characterized!
- Measurements at high water contents are possible and reproducible.
- Data can be used as input for modelling of defined extrusion shapes!

From flow data to product

D. Tammaro
G. D'avino
P.L. Maffetone





INPUT

- Flow data
- processing conditions
- geometry

CFD modelling

OUTPUT

- velocity field
- pressure field

Design and engineering

Die design

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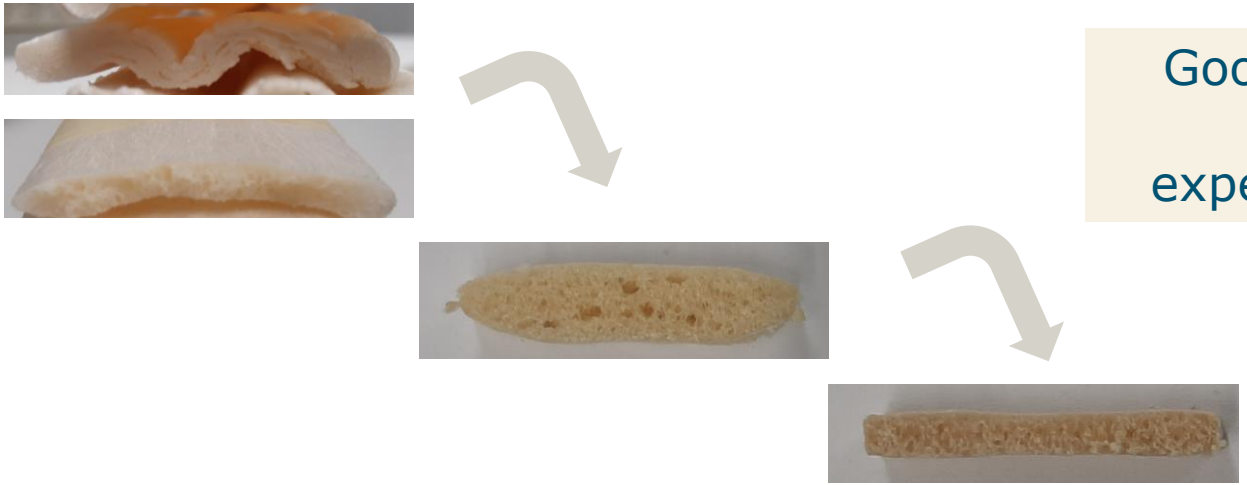
Towards foams with defined shapes



Good match with experiments!

- Instead of empirical approach, parts design from material knowledge
- Good match with experiments
- Next step predict product properties

Project ZEVER – Dynamic packaging films

Project goal :

"Development of a pilot scale production process of a 100 % certified renewable packaging film based on side stream starches."

Project period: 01/2020 – 12/2021

Project partners

Rijksdienst voor Ondernemend Nederland

RODENBURG Biopolymers

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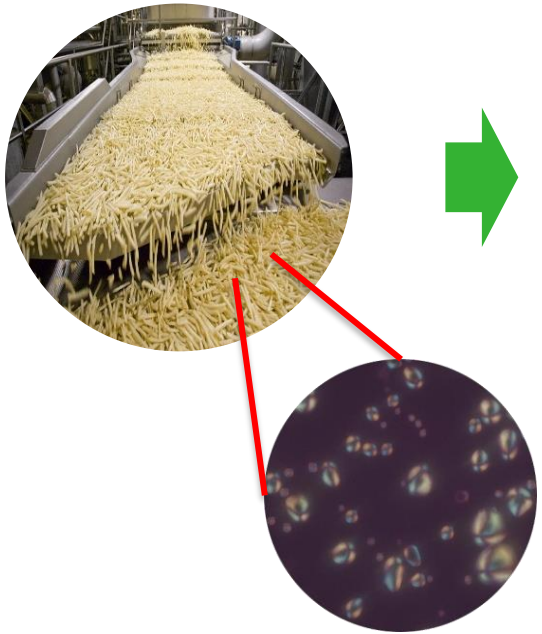
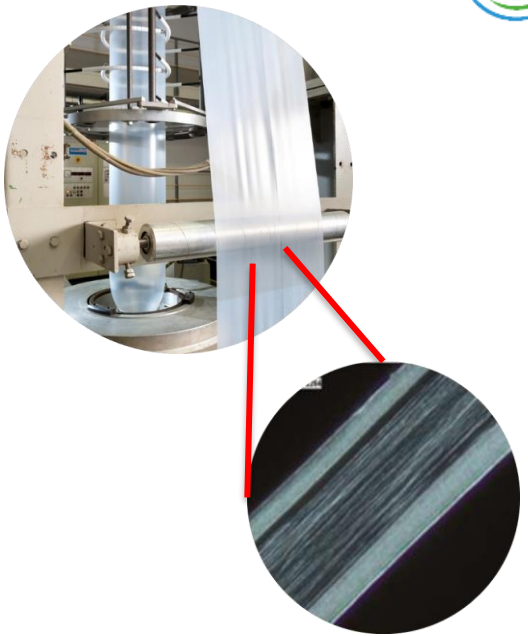
Side stream starch providing a barrier layer

Production potato products



Production pellets based on side stream starch

Production packaging film



Fresh on demand

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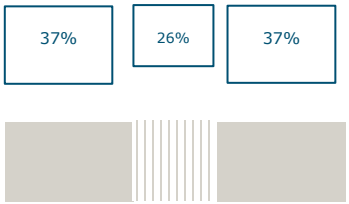
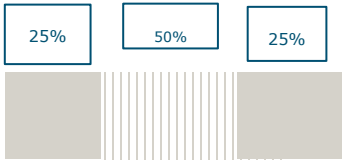
Patent: WO2020002630 (A1) - Dynamic modified atmosphere packaging for fresh horticultural products

Dynamic packaging concept

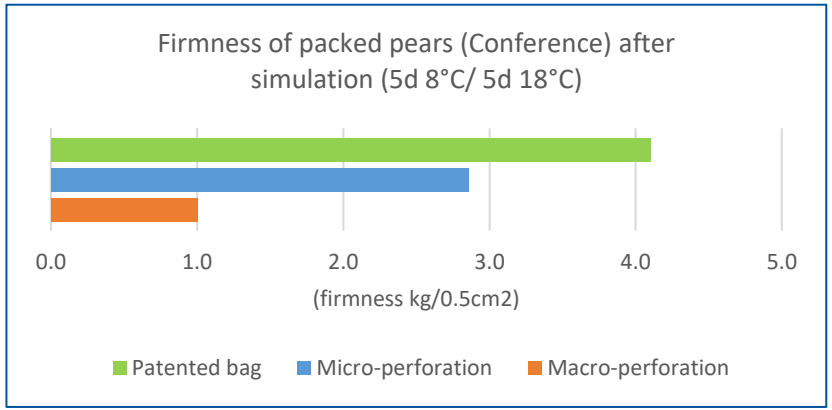
- Three layer films:
  - outside (moisture protection): hydrophobic polymer mixture
  - inside (dynamic barrier): mixture of starch, hydrophobic polymer and additives
  - Oxygen and carbon transmission rates can be tuned by changing the film/layers thickness or compositions.





Patent: WO2020002630 (A1) - Dynamic modified atmosphere packaging for fresh horticultural products

Films with tuneable barrier properties



- Pears stay longer firm and green when packed into patented bags
- Shelf life of fresh food products can be extended

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Patent: PCT/EP2019/067393

Products in the market

Edible dog chews

Foams

Starch endless opportunities!

- Rheological measurements help to improve and understand processing and properties of starch based thermoplastic products
- Foams, films, injection moulding and other processes can profit from optimizing the flow properties of the starch source / starch compounds
- Connecting fundamental material properties to processing and product performance is essential for advancing market applications
- *Unexplored side streams or alternative crops containing starch offer unique opportunities for new market applications*

Questions?

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